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A STUDY OF THE MOSAIC DISEASE OF ABACÁ, OR MANILA HEMP PLANT (MUSA TEXTILIS NÉE), WITH SPECIAL REFERENCE TO SOURCES OF INOCULUM AND POSSIBLE TRANSMISSION OF THE VIRUS BY MECHANICAL MEANS[1]

JORGE P. JULIANO

THE DISEASE

Economic importance, history, and distribution

The mosaic disease of abacá, or Manila hemp plant (*Musa textilis* Née), is the most important disease which threatens with ruin the abacá industry of the Philippines today. According to Dr. Otto A. Reinking, Foreign Agricultural Adviser of the Philippine Government, the abacá mosaic situation in Davao and Cotabato in Mindanao is critical and needs immediate attention.[2],[3] Infection of abacá with mosaic in Davao ranged from 15 to 90 per cent of the stools in some plantations to almost total in others (Ocfemia, 1949). In 1934, Calinisan of the Bureau of Plant Industry called attention to the occurrence in 1933 of abacá mosaic in Davao.

Ocfemia and Celino (1938) first transmitted the disease with *Aphis gossypii* Glover. In addition to *Aphis gossypii*, Celino (1940) and Celino and Ocfemia (1941) transmitted abacá mosaic with *Rhopalosiphum nymphaeae* (Linn.) but failed to communicate the disease with *Pentalonia nigronervosa* Coq., *Ferrisia virgata* (Cockerell), *Aphis laburni* Kaltenbach, and *Stephanitis typica* (Distant). In the same year Celino and Ocfemia showed that *Aphis maidis* Fitch and *Rhopalosiphum prunifoliae* Fitch can also transmit abacá mosaic. These authors, however, failed to communicate abacá mosaic by mechanical methods.

With the use of appropriate aphid vectors, Ocfemia (1949) showed that corn mosaic and *Canna indica* Linn. mosaic can be transmitted to abacá. In 1930, Magee described the infectious chlorosis of banana in Australia, a disease resembling the mosaic of abacá in the Philippines. He claimed to have transmitted the disease with *Pentalonia nigronervosa*, but later stated that this aphid was probably not an important vector in the field. Magee (1940) reported that he transmitted the banana mosaic with *Aphis gossypii* from the Cavendish banana to a seedy species of *Musa;* from the seedy *Musa* to abacá, *Canna indica*, cucumber, squash, tomato, and banana. Celino (1940) failed to transmit to bananas the abacá mosaic in the Philippines.

[1]Experiment Station Contribution No. 1572. Thesis presented for graduation with the degree of Bachelor of Science in Agriculture, from the College of Agriculture, April, 1951. Prepared in the Department of Plant Pathology under the direction of Dr. G. O. Ocfemia.

[2]REINKING, O. A. 1949. Abacá disease studies: Davao, Philippine Islands. Plant Disease Reporter **33** (12): 456–462. (Mimeographed.)

[3]REINKING, O. A. 1950. Abacá mosaic in Davao and Cotabato Provinces. (Mimeographed.)

Symptoms, cause, and known methods of communication

Ocfemia and Celino (1938), Calinisan (1939), and Celino (1940) presented precise descriptions of the abacá mosaic in the early and advanced stages of the disease. Ocfemia and Celino (1938), Celino (1940), and Celino and Ocfemia (1941) attributed abacá mosaic to the virus *Marmor cucumeris* Holmes and reported the transmission of the disease by the aphids *Rhopalosiphum nymphaeae* (Linn.), *R. prunifoliae* Fitch, *Aphis gossypii* Glover, and *A. maidis* Fitch. Ocfemia, in 1949, added that... "abacá is probably not a normal host of these aphids. Under stress of absence of their customary hosts, however, they may provisionally take to feeding on abacá and in this way transmit the mosaic from abacá to abacá, or from any other source of inoculum to abacá." The abacá mosaic virus is systemic; owing to organic connections in the corms, all suckers produced by infected plants sooner or later exhibit the symptoms of mottling. The transmission of the disease through the true seeds has not been demonstrated.

Objects of the present study

The transmission to abacá of the mosaic of corn and mosaic of *Canna indica* suggests that the mosaic of abacá may be caused by any strain of the virus, *Marmor cucumeris*, which has been modified by association with cultivated and wild hosts, and grass mosaic from corn and other graminaceous weeds (Ocfemia, 1949). Once on abacá, the virus can continue to infect abacá and perhaps even develop strains more or less specialized on this host. A study was therefore made in the Department of Plant Pathology of the College of Agriculture at Los Baños, from December, 1949, to February, 1951, to determine what other mosaics besides those of *Canna indica* and of corn may be transmitted to abacá. As the present measures for the control of abacá mosaic in Mindanao are based chiefly on the spread of the disease by aphids and by the use of infected plants, it was determined whether or not the viruses of abacá mosaic and of other mosaics may be communicated to abacá by mechanical methods of transmission.

EXPERIMENTS ON TRANSMISSION

Experiments with Aphis gossypii Glover and A. maidis Fitch[4]

In aphid transmission experiments conducted under controlled conditions, 70 potted abacá seedlings grown from disease-free seeds obtained from the Bicol Provinces and from the Department of Agronomy of this College, were used. The potted plants were placed in shallow pans of water for sub-irrigation and covered with cheesecloth bags to prevent infestation by other insects. This method of culturing abacá was found to be very satisfactory in keeping the plants healthy and in preventing other insects from interfering with the experiments.

The methods of transferring the aphids from the different sources of inoculum to the experimental plants were the same as those described by Ocfemia (1930) in abacá bunchy-top transmission experiments. For the control, aphids which had fed on healthy hosts were transferred to abacá. The aphids were allowed to remain on the experimental and check plants

[4]The aphid vectors used were identified by Dr. Leopoldo B. Uichanco of the Department of Entomology, College of Agriculture, to whom thanks are due.

indefinitely. However, difficulty was encountered in keeping them alive for a few days even in damp chambers because the transfers sometimes involved three changes of hosts: from their natural hosts to the different sources of inoculum for securing the virus, and then to the experimental abacá seedlings. Ten to fifteen young and adult aphids were colonized on each experimental abacá seedling. Ocfemia, Macaspac, and Hsieh (1941) found that at least five *A. gossypii* which had fed on mosaicked *Canna indica* for about five minutes could transmit the disease to abacá.

Results of experiments with apids

Experiment 1. On August 31, 1950, four healthy abacá seedlings were used for colonizing on each plant 10 to 15 young and adult *Aphis gossypii* which had fed on mosaicked abacá for 48 hours. The same number of aphids from healthy abacá were transferred to two healthy abacá seedlings for control. Definite symptoms of mosaic appeared on three plants after an incubation period of from 15 to 18 days, whereas the checks remained healthy.

Experiment 2. On December 16, 1950, and again on January 28, 1951, 15 *Aphis gossypii* which had fed on mosaicked abacá for 48 hours were transferred to each of 12 healthy cucumber seedlings. No symptoms of infection appeared on the experimental cucumber seedlings even after 45 days.

Experiment 3. On December 9, 1950, 15 individuals of *Aphis gossypii* from healthy watermelon were allowed to feed on mosaicked *Hippeastrum* sp. for 48 hours and then transferred to each of six healthy five-month-old abacá seedlings. In addition, three healthy abacá seedlings were planted in the same pot beside the mosaicked *Hippeastrum* where large numbers of *Aphis gossypii* had been allowed to colonize. The experimental plants remained as healthy as the checks even after three months.

Experiment 4. On December 11 and 13, 1950, 15 *Aphis gossypii* which had fed on mosaicked *Canna indica* obtained from Davao, through the courtesy of Dr. Gonzalo Merino of the Bureau of Plant Industry, were colonized on each of nine healthy abacá seedlings. Two abacá seedlings showed symptoms of infection after 28 and 29 days of incubation, whereas the checks remained healthy. Ocfemia, Macaspac, and Hsieh (1941) transmitted the mosaic of *Canna indica* to abacá with *Aphis gossypii* and described precise symptoms of the disease on both hosts.

Experiment 5. On December 10, 1950, large numbers of *Aphis gossypii* taken from healthy watermelon were allowed to feed for 48 hours on an ornamental *Canna* showing symptoms of mosaic distinct from that described by Ocfemia, Macaspac, and Hsieh (1941), but resembling the mosaic of *Canna glauca* Linn. described by Brierley and Smith (1947) in the United States. Ten virus-laden aphids were transferred to each of three healthy abacá seedlings, and non-viruliferous aphids from healthy watermelon were transferred to another abacá for control. *Aphis gossypii* failed to effect transmission of the disease from the ornamental *Canna* to abacá. Neither did Brierley and Smith (1947) succeed in their attempts to transmit the mosaic of *Canna glauca* to abacá with *Aphis gossypii*, although these authors believe that the mosaics of *Canna glauca* in the United States and of *Canna indica* in the Philippines are identical.

Experiment 6. As *Aphis gossypii* is the vector of the infectious chlorosis of bananas in Australia, it was thought that this aphid could possibly transmit to abacá a suspected mosaic of banana hitherto unreported in the Philippines. Hence, on December 28, 1950, and again on January 10, 1951, 15 individuals of *Aphis gossypii* which had fed for 24 to 48 hours on the mosaicked banana were transferred to each of seven healthy abacá seedlings. Unlike in experiment 4, no symptoms of mosaic were shown by any of the experimental plants even one month after the inoculation.

Experiment 7. On November 13, 1950, 15 *Aphis maidis* taken from corn and allowed to feed for 24 hours on mosaicked sugar cane were transferred to each of five healthy abacá seedlings about four months old. Ten aphids which had been colonized on healthy sugar cane were transferred to a healthy abacá seedling for control. The corn mosaic virus which is reported by Lawas and Fernandez (1949) as identical with the sugar cane or grass mosaic virus is transmitted by *Aphis maidis* from corn to abacá and to sugar cane, but not from sugar cane to abacá. The inability of *Aphis maidis* taken from corn to feed for longer periods on mosaicked sugar cane and on the experimental abacá plants perhaps accounts for the failure to transmit the mosaic. It is also probable that the grass mosaic virus from sugar cane must pass through corn before it can be transmitted to abacá. Bawden (1950) noted that the dandelion yellow mosaic virus was not readily transmitted from dandelion to dandelion, although Kassanis in 1947 transmitted the disease from dandelion to lettuce and from lettuce to dandelion.

Experiment 8. On September 7, 1950, two healthy abacá seedlings were used for colonizing on each plant a number of adults of *Aphis maidis* which had been reared for 48 hours on mosaicked *Paspalum conjugatum* Berg. As the experimental and check plants remained healthy even three months after they had been used in the experiment, the test was repeated on December 17, 1950, on three other healthy abacá plants. Negative results were likewise obtained.

Experiment 9. On September 11, 1950, 15 *Aphis maidis* which had fed on mosaicked *Panicum* sp. for 72 hours were transferred to each of two healthy abacá seedlings. The inoculated plants and the check remained healthy even after three months. Further tests were not made owing to the death of the source of inoculum.

Failure of transmission by mechanical methods

The transmission of the mosaic of abacá by mechanical methods other than by brief contact of wounded surfaces of abacá and through the use of contaminated implements are of no consequence in the spread of the disease in the field.

For sources of inoculum in mechanical transmission experiments, mosaicked plants belonging to seven families were collected from the vicinity.

1. Musaceae
   Abacá, *Musa textilis* Née.
   Banana, *Musa sapientum* Linn.
2. Gramineae
   Corn, *Zea mays* Linn.
   Sugar cane, *Saccharum officinarum* Linn.

Panicum sp.
Kulape, *Paspalum conjugatum* Berg.

3. Amaryllidaceae
Hippeastrum sp.
Amazon lily, *Eucharis grandiflora* Planch.

4. Cannaceae
Canna indica Linn.
Ornamental *Canna*

5. Cruciferae
Pechay, *Brassica juncea* (Linn.) Coss.

6. Cucurbitaceae
Ampalaya, *Momordica charantia* Linn.

7. Solanaceae
Tobacco, *Nicotiana tabacum* Linn.

The resistant viruses, like the tobacco mosaic virus, are very readily transmitted by mechanical means. Fernow (1925) believes that transmission by mechanical methods which involves touching the plants with the hands is unsatisfactory because the virus may be carried from one experiment to the next. In order to minimize contamination of one virus by another, the writer performed the mechanical transmission tests on separate days. The instruments were sterilized by flaming them over an alcohol lamp or by boiling in water for about 20 minutes. The hands were thoroughly washed with soap and water and finally rinsed with alcohol before and after each inoculation. In all the experiments the checks were treated first.

Experiment 1. By needle pricks. From May, 1950, to January, 1951, two to three leaves of each of three to four healthy abacá seedlings were inserted between the folds of fresh mosaicked leaves of the source of inoculum. The diseased leaves were pricked rapidly through to the other side with a dozen pins mounted on a piece of wood. The control plants were pin-pricked between the folds of healthy leaves.

After a period of three to five months, no symptoms of infection were shown by any of the experimental plants. The results indicated that the mosaic viruses from the different hosts collected could not be transmitted to abacá by needle pricks.

Experiment 2. With crushed tissues. From June, 1950, to January, 1951, crushed fresh tissues from each source of inoculum were each rubbed against the lower and upper surfaces of the leaves of each of two to five healthy abacá seedlings. In parallel transmission experiments with the same number of abacá plants, the leaves were abraded with 300-mesh carborundum before they were rubbed with crushed tissues of the source of inoculum. In both series of these experiments, the experimental and the check plants remained healthy even after three to five months.

Experiment 3. By sap injection. From July, 1950, to January, 1951, each of three to seven healthy abacá seedlings was injected with a hypodermic syringe with undiluted sap expressed through cheesecloth from each of the different sources of inoculum. Abacá seedlings injected with

extracts from healthy plants served as control. From 0.5 to 3 cc. of sap was injected into each abacá seedling, depending upon the age and size of the plants.

Injections deep into the heart resulted in the bleaching of the whole or portions of the young leaf that developed subsequent to inoculation; those injected in the petioles and midribs showed no appreciable injury. Sometimes the leaf became mottled temporarily, but it soon recovered the normal green color. Not one of the injected abacá plants showed the early dot-like symptoms of abacá mosaic.

Experiment 4. By insertion of diseased tissues. In May, 1950, mosaicked abacá tissues were inserted into the pseudostems of three healthy abacá plants with a flamed and cooled scalpel. Healthy abacá tissues were similarly inserted into another plant to serve as control. No transmission of the disease occurred even after two months.

Experiment 5. By grafting. On January 13, 1951, mosaicked petioles of *Canna indica*, of abacá, and of young stems of mosaicked corn were grafted to the petioles of each of three healthy abacá seedlings. Melted paraffin was used for sealing the wounded parts. Tap water was introduced by means of short glass tubings into the diseased scions. No transmission was noted even after one month.

The failure to transmit to abacá the viruses of abacá mosaic and of other mosaics by mechanical methods corroborates the result obtained by Ocfemia and Celino (1938), who failed to transmit abacá mosaic by pinpricks and by injection of expressed juice. The same authors, however, were able to transmit the abacá mosaic virus by a modified grafting method. The wounded surfaces of the midribs of a healthy and a diseased abacá were fitted together, held firmly with paper clips, and allowed to remain in contact for 28 days. This grafting method of mechanical transmission communicated the disease probably because it effected immediate transfer of an infective dose of the virus from the infected to the healthy abacá, with the least exposure of the virus to the air and without much injury to the tissues which released the infective substance.

The failure of the abacá mosaic virus to be readily transmitted to abacá by mechanical means may perhaps be regarded as an inherent property of the virus itself. The inability of the other viruses to infect abacá may perhaps be attributed, too, on the one hand, to the properties of the experimental plants which inhibit or inactivate the virus, and on the other hand, to the intrinsic properties of the virus itself. It was not determined in this work whether one or a combination of these two factors accounts for the failure of the virus to cause infection on abacá by mechanical methods of transmission. Doolittle and Walker in 1925 found that cucumber mosaic virus was readily transmissible between most hosts, but they could hardly transmit it from *Phytolacca* sp. to tobacco because extracts of these plants contain substances that interact with the virus and render it non-infective (Bawden, 1950). Bawden (1950) states that the properties of the virus and of the host plants often determine mechanical transmissibility.

Although the mosaic viruses of abacá, corn, and *Canna indica* are readily transmitted to abacá if appropriate aphid vectors are used, attempts to transmit them to abacá by mechanical methods failed. Bawden (1950) attributes the failure to transmit mechanically viruses that are transmitted

by insects to one or to a combination of the following factors: "... the viruses may occur at too great a dilution in plant extracts, they may inactivate too rapidly, they may encounter substances that inhibit infectivity, or they may need to be introduced into some specific tissue."

SUMMARY

1. Mosaic is the most important disease of abacá in the Philippines today. It is caused by the virus *Marmor cucumeris* Holmes transmitted experimentally by four species of aphids—two from abacá to abacá and two from *Canna indica* Linn. and corn to abacá.

2. No new source of inoculum was found in this work.

3. In aphid transmission experiments, *Aphis gossypii* Glover failed to transmit to abacá the mosaic viruses from *Hippeastrum* sp., ornamental *Canna*, and banana. Neither did this aphid transmit abacá mosaic to cucumber. Although *Aphis maidis* Fitch can transmit corn mosaic to abacá and back to corn again, it failed to transmit to abacá the grass mosaic from sugar cane and *Paspalum conjugatum* Berg., and the mosaic of *Panicum* sp.

4. The mosaic of abacá cannot be communicated by the usual mechanical methods of transmission. Attempts to transmit mechanically the mosaic viruses to abacá from ampalaya (*Momordica charantia* Linn.), banana, ornamental Canna, *Canna indica* Linn., *Eucharis grandiflora* Planch., *Hippeastrum* sp. *Panicum* sp., *Paspalum conjugatum* Berg., pechay (*Brassica juncea* [Linn.] Coss.), sugar cane, corn, and tobacco, likewise, gave negative results. It is not known if insects other than *Aphis gossypii* and *A. maidis* can transmit to abacá the mosaic diseases of these plants.

5. The failure to transmit to abacá the virus from abacá and other sources of inoculum by means of pin-pricks, crushed tissues, sap injection, insertion of diseased tissues, and grafting is important in control work. The present measures for the control of the mosaic disease of abacá in the field based on the known methods of spread, namely, (a) by four species of aphids from two sources of inoculum, *Canna indica* and corn, and (b) by use of suckers from superficially healthy but infected stools, still remain unchanged.

LITERATURE CITED

Bawden, F. C. 1950. Plant viruses and virus diseases. 3rd ed. xv + 335. p., 59 fig. Waltham, Massachusetts: Chronica Botanica Company.

Brierley, P., and F. F. Smith. 1948. Canna mosaic in the United States. Phytopath. **38** (3): 230–234. *Fig. 1.*

Calinisan, M. R. 1934. Notes on a suspected "mosaic" of abacá in the Philippines. Philippine Jour. Agr. **5**: 255–258. *Pl. 1.*

Calinisan, M. R. 1939. Transmission experiment of abacá mosaic. Philippine Jour. Agr. **10**: 121–130. *Pl. 1–9.*

Celino, M. S. 1940. Experimental transmission of the mosaic of abacá, or Manila hemp plant (*Musa textilis* Née). Philippine Agriculturist **29** (5): 379–403. *Pl. 1–5.*

Celino, M. S., and G. O. Ocfemia. 1941. Two additional insect vectors of mosaic of abacá, or Manila hemp plant, and transmission of its virus to corn. Philippine Agriculturist **30** (1): 70–79. *Pl. 1.*

Fernow, K. H. 1925. Interspecific transmission of mosaic diseases of plants. Cornell Agric. Exper. Sta. Memoir 96: 1–34. *Pl. 1–7.*

LAWAS, O. M., AND W. L. FERNANDEZ. 1949. A study of the transmission of the corn mosaic and some of the physical properties of its virus. Philippine Agriculturist **32**: 231–238. *Fig. 1–3.*

MAGEE, C. P. J. 1930. A new virus disease of bananas. Agric. Gaz. New South Wales **11**: 929.

MAGEE, C. P. J. 1940. Transmission of infectious chlorosis or heart-rot of the banana and its relation to cucumber mosaic. Jour. Australia Inst. Agric. Sci. **6**: 44–47. *Fig. 1–2.*

OCFEMIA, G. O. 1930. Bunchy-top of abacá, or Manila hemp: I. A study of the cause of the disease and its method of transmission. Amer. Jour. Bot. **17**: 1–18. *Pl. 1–4.*

OCFEMIA, G. O., I. S. MACASPAC, AND HSIEH FENG YUAN. 1941. Experimental transmission of the mosaic of *Canna indica*. Philippine Agriculturist **30**: 357–370. *Pl. 1–2.*

OCFEMIA, G. O. 1949. The rapid dissemination of the mosaic disease of abacá, or Manila hemp plant (*Musa textilis* Née), in the field. Philippine Agriculturist **33**: 142–144.

STUDIES ON THE CONTINUOUS EXTRACTION OF COCONUT OIL WITH THE USE OF ETHYL ALCOHOL[1]

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Of the Department of Agricultural Chemistry

WITH FIVE TEXT FIGURES

The appreciable solubility of coconut oil in 95 per cent ethyl alcohol at boiling point and the relatively high freezing point of the oil suggest the use of ethyl alcohol in the continuous extraction of coconut oil in a low-temperature recovery system. Hence a study was conducted in the Agricultural Chemistry Laboratory of the College of Agriculture from November, 1947, to October, 1948.

Carañgal and Banzon (1949) showed the feasibility of extracting coconut oil with the use of alcohol. They obtained oil of good quality, water-white, not acidic, and without the odor usually associated with heated oil. They also observed that thin-sliced copra was not so suitable for solvent extraction as coconut shreds.

Bailey (1945) described the following commercially used continuous solvent-extraction systems: (*1*) the Bollman (or Hansa-Mühle), (*2*) the Hildebrandt, (*3*) the Fauth, (*4*) the Bonotto, (*5*) the Allis-Chalmer (modified Bonotto), (*6*) the Kennedy, (*7*) the Ford, (*8*) the Böhn, and (*9*) the Miag.

EXPERIMENTS AND RESULTS

Materials and general outline of procedure

In the present study, the samples for extraction were prepared by grating mature coconuts and drying the shreds. The samples were kept in containers.

Commercial ninety-five per cent ethyl alcohol and ether were used as solvent.

Among the analytical apparatus used were Soxhlet extractors and an analytical balance.

Before proceeding with the extraction, the percentage of oil in the sample and the purity of the alcohol used were determined according to the method described in the sixth edition of the *Official and Tentative Methods of Analysis of the Association of Official Agricultural Chemists*, 1945.

The oil from the shreds was extracted in the experimental systems by the action of alcohol at boiling point. The solvent was recovered by cooling the miscella to about 18°C. until the oil separated by solidification. A constant amount of coconut shreds, 50 grams, was used in all extractions. To simplify the study, fresh solvent was used in portions of 100 ml. whenever continuous extraction was not possible. Cloudiness in the miscella upon

[1]Experiment Station Contribution No. 1573. Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, October, 1948. Prepared in the Department of Agricultural Chemistry under the direction of Assistant Professor Julian Banzon.

cooling indicated the presence of extracted oil and the feasibility of continuing the extractions. A clear solution was an evidence that no more oil could be extracted by the solvent and hence extraction could be stopped. At least three replications were made for each experiment.

First experimental system

The system consisted of three main parts as shown in figure 1. The parts were so arranged as to facilitate the free flow of the solvent and miscella and the application of the new solvent.

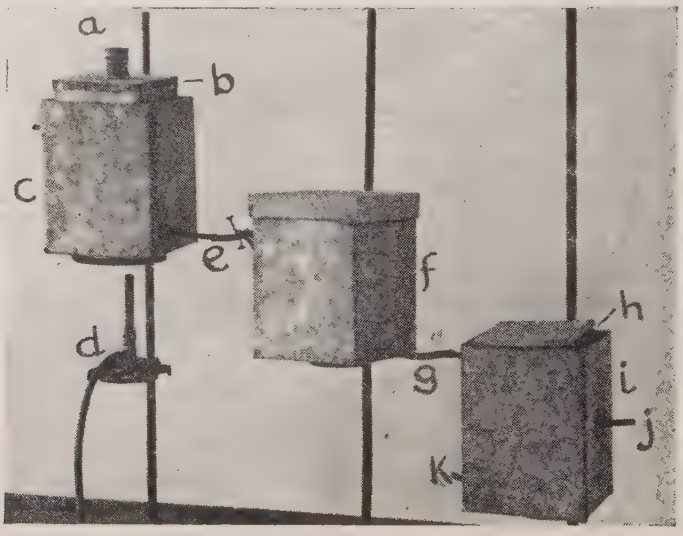

Fig. 1—The extraction assembly used in the first experimental system, showing: (a) thermometer, (b) solvent chamber, (c) water bath, (d) burner, (e) passage for hot solvent, (f) extraction chamber, (g) passage for miscella, (h) miscellar reservoir, (i) ice cube container, (j) solvent outlet, and (k) oil outlet.

Heating chamber. A rectangular container provided with an outer wall for water bath (fig. 1, *c*) and with a piece of glass tubing as a safety valve served as the heating chamber, or solvent chamber (fig. 1, *b*). Heat was furnished by a burner (fig. 1, *d*). The solvent was brought to boiling and then made to flow to the extraction chamber (fig. 1, *f*). One hundred ml. of solvent at a time was heated and used for extraction. A total of 600 ml. was used.

Extraction chamber. The hot solvent was allowed to flow over the shredded sample contained in a wire-screen basket placed inside a rectangular metal container. The screen permitted the flow of the solvent or miscella to the separatory chamber and held back the shreds. The sample was replaced after draining the solvent. The extraction temperature was 70°C

Separatory chamber. The miscella was collected in a compartment, or miscellar reservoir (fig. 1, *h*), provided with a solvent outlet (fig. 1, *j*) and an oil outlet (fig. 1, *k*). An outer wall, or ice-cube container (fig. 1, *i*), formed a space where ice cubes were placed to maintain the required low temperature. The oil froze out satisfactorily up to the level of the solvent outlet. The oil in the miscella above the level of the solvent outlet flowed out because there was no sufficient time for it to cool. It was evident that extraction was faster than solidification, hence the miscellar flow had to be regulated. The oil remained solid and had to be scraped off, thus causing intermittent operation. Nevertheless, the amount extracted by the percolating hot solvent was determined. The moisture condensation occurred during the separation of the oil from the solvent.

An average of 90.5 per cent extraction was obtained. Of the 600 ml. used, 50.6 ml. was retained by the shreds and oil. The loss of 28.3 ml. of the solvent was attributed to evaporation and to adherence to the walls of its containers during transference. This system was found unsatisfactory because extraction could not be made continuous, and the scraping of the frozen oil did not work well.

Second experimental system

A second system devised, as shown in figure 2, gave special attention to the extraction chamber.

Heating chamber. The solvent was heated in a rectangular container (fig. 2, *a*) provided with a safety valve, a thermometer, and an electric heater (fig. 2, *c*). At boiling point, the solvent was allowed to flow through a cock (fig. 2, *b*) to the extraction system.

Extraction chamber (Extractor). Six rectangular containers (fig. 2) attached to a revolving hexagonal frame (fig. 2, *f*) were used for extraction. The shreds were placed in the extraction containers and submerged in the hot solvent. The shreds and the miscella were thrown as the frame was rotated into a conveyor (fig. 2, *d*). The shreds were retained in the conveyor by a wire screen attached to it, and the miscella was allowed to drip in the separatory chamber. The shreds were taken back and subjected to maximum solvent extraction.

Separatory chamber. The separation of oil was accomplished as in the first system.

An average extraction of 87.8 per cent was obtained. Of the 600 ml. solvent used, 487.6 ml. was recovered from the miscella and 61.1 ml. was retained by the shreds and oil, giving a loss of 51.5 ml.

In this experiment the temperature of extraction dropped to 65°C.; this caused a lower percentage of extraction. There was a greater loss of solvent because of the large exposed area of the system. The operation was discontinued on account of the inconvenience of repeatedly taking back the shreds to the system for maximum solvent extraction and of stopping the flow of the hot solvent after submerging one container with samples.

Third experimental system

The third system shown in figure 3 consisted of a solvent chamber, an ice-water reservoir, an extraction chamber, and a separatory chamber.

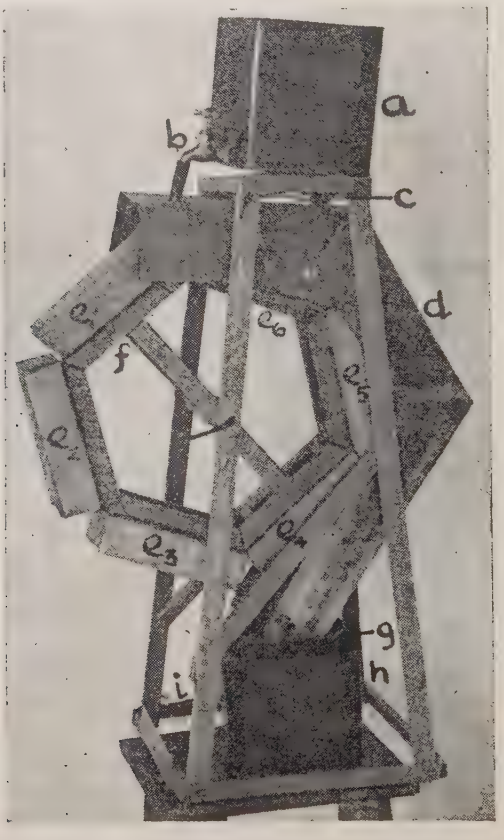

Fig. 2—The extraction assembly used in the second experimental system, showing: (a) heating chamber, (b) passage for hot solvent, (c) heater, (d) conveyor, (e_1, e_2, e_3, e_4, e_5, e_6,) extraction cans, (f) rotary frame, (g) miscellar reservoir, (h) ice cube container, and (i) solvent outlet.

Solvent chamber. A small tin can or heating chamber (fig. 3, *c*), where the solvent was heated 100 ml. at a time, served as the solvent chamber. It was provided with a safety valve (fig. 3, *b*) and a thermometer (fig. 3, *a*). The solvent was allowed to flow into the extraction chamber at its boiling point (78°C.).

Extraction chamber. This was a small tin can (fig. 3, *e*) provided with a perforated partition which permitted the passage of the miscella and retained the shreds. The shreds were placed in a cylindrical wire-screen container. The miscella was collected at the lower portion of the can and allowed to flow through the separatory chamber. The sample was changed after the solvent had been drained.

Separatory chamber. This chamber was made up of two cans of different sizes. The smaller one, or the chilling roll (fig. 3, *i*), was placed inside the bigger one, or the miscellar reservoir (fig. 3, *h*), in such a way that it could be rotated freely. A scraper (fig. 3, *j*) was attached to one side of the

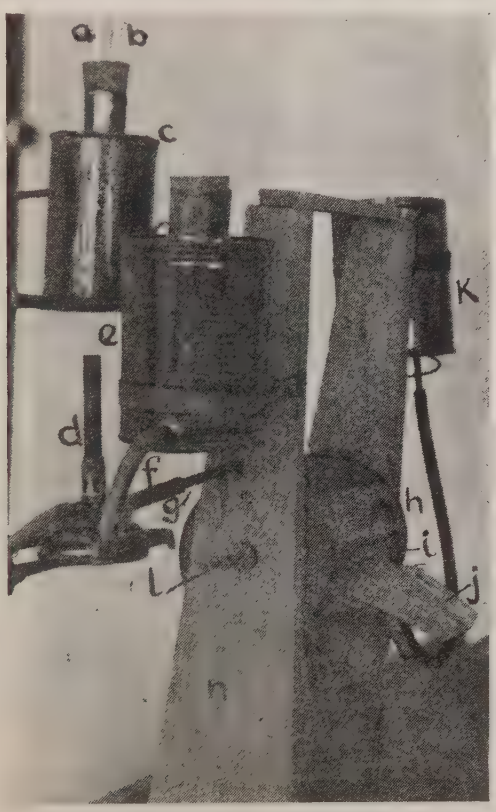

Fig. 3—The extraction assembly used in the third experimental system, showing: (a) thermometer, (b) safety valve, (c) solvent chamber, (d) burner, (e) extraction chamber, (f) passage for hot solvent, (g) sprayer (tube with holes), (h) miscellar reservoir, (i) chilling roll, (j) scraper, (k) ice-water reservoir, (l) shaft, (m) solvent outlet, and (n) support.

outer can. The smaller can was filled with ice-water through the tubes which served as the shaft (fig. 3, *l*). The miscella was sprayed over the chilling roll through a tube with holes (fig. 3, *g*.).

The difficulty with this separator is that the surface temperature in the chilling roll could not be lowered sufficiently enough to solidify the oil.

Different modifications were made to lower the temperature. First, a third can was placed inside the chilling roll to effect a continuous flow of ice water. Then the outlet for the solvent was placed higher than that for the miscella. These modifications were not satisfactory, although there were traces of solidified oil clinging around the wall of the chilling roll.

The performance of the extractor was determined in spite of the failure of the system. The percentage of extraction was 93.7. Of the 600 ml. solvent used, 500.3 ml. was recovered from the miscella, 63.4 ml. was retained in the oil and shreds, and 31.2 ml. could not be accounted for.

Fourth experimental system

The fourth system retained the solvent and extraction chambers of the third system.

Separatory chamber. The new separatory chamber consisted of three cans (numbered *1*, *2*, *3*), one inside the other. The miscella was collected in the outermost can (fig. 4, *1*). The sides and bottom of the middle can

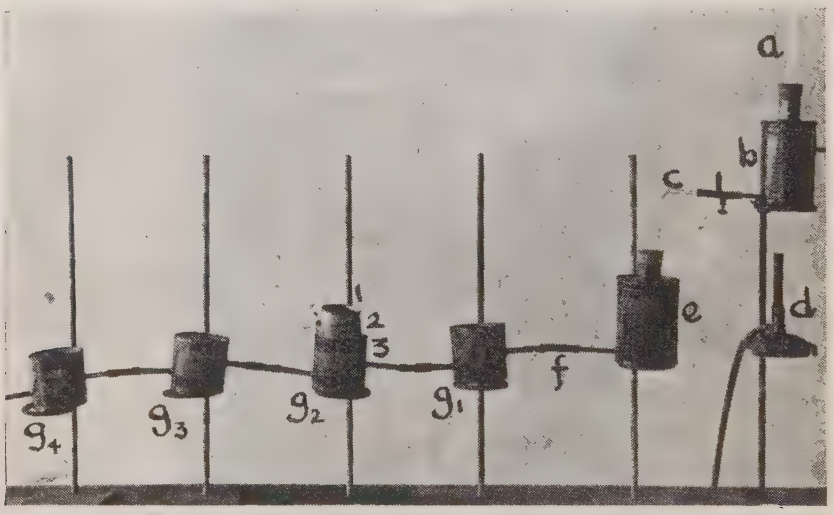

Fig. 4—The extraction assembly used in the fourth experimental system, showing: (a) thermometer, (b) solvent chamber, (c) passage for hot solvent, (d) burner, (e) extraction chamber, (f) passage for miscella, and (g_1, g_2, g_3, g_4) separator, a series of four sets of three (1,2,3) different-sized cans placed one inside the other.

(fig. 4, *2*) were perforated. Ice cubes were placed in the third can (fig. 4, *3*). The oil solidified inside the perforated can and around the third can. To freeze out completely the oil in the miscella, a series of four sets (fig. 4, g_1, g_2, g_3, g_4) of such freezing cans was used. The oil was removed by changing the middle and third cans with new ones and scraping off the solidified oil from them.

In this system it was noted that moisture condensed in the separatory chamber. The system was really a series of intermittent extractions and separations. The separation of the oil from the solvent was incomplete because of the presence of solidified matter other than oil.

The percentage of extraction was 92.9. Of the 400 ml. of solvent used, 51 ml. was retained, 344 ml. was recovered, and 4.8 ml. could not be accounted for. Only 400 ml. of solvent was used because it was observed

that the last 200 ml. of solvent used for extraction gave a miscella of almost similar nature as the fourth 100-ml. portion.

Fifth experimental system

A fifth system was devised in order to solve the problems encountered in the fourth system regarding the replacements of the samples and the removal of the solidified oil.

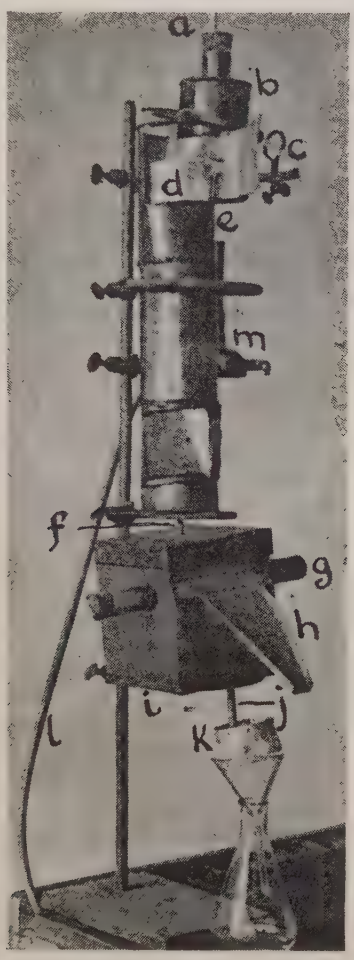

Fig. 5—The extraction assembly used in the fifth experimental system, showing: (a) thermometer, (b) solvent chamber, (c) passage for hot solvent, (d) extraction can, (e) extraction tube, (f) passage for miscella, (g) shaft, (h) scraper, (i) rectangular container for the chilling roll, (j) passage for solvent, (k) filter assembly, (l) rubber tubing, and (m) burner.

Heating chamber. The solvent was heated in a small tin can (fig. 5, *b*) provided with a safety valve, a thermometer (fig. 5, *a*), and a burner (fig. 5, *m*.).

Extraction chamber. A series of small tin cans or extraction cans (fig. 5, *d*) with perforated bottoms was inclosed in a long tube, the extraction tube (fig. 5, *e*), which served as the extraction chamber. The perforation permitted the passage of solvent and miscella but held back the shreds. The hot solvent was allowed to flow to the topmost can and the miscella, to drip to the separatory chamber.

Separatory chamber. A small chilling can, or chilling roll, was placed inside a large can cut transversely so that the former could be rotated freely. The chilling can was filled with ice cubes through the tubes which served as shaft (fig. 5, *g*). These cans were inclosed in a rectangular container where the dripping solvent was collected after it had passed through the small holes provided along the sides of the transversely cut can. A scraper (fig. 5, *h*) was provided for removing the solidified oil.

Solidified matter other than oil interfered with the separation of the oil and solvent. When warmed, this substance liquefied or melted faster and formed a layer above the oil. To eliminate this substance which was suspected to be protein or carbohydrate, both of which are soluble in alcohol in the presence of moisture, a portion of the sun-dried shreds was oven-dried. Oven-drying the sample, however, did not remove this substance from the miscella. Since protein and carbohydrate are insoluble in ether, a mixture of alcohol and ether (50:50) was used for extraction to decrease their solubility. The addition of ether did not give satisfactory results either.

The low melting point of this substance was taken advantage of by separating it from the oil with the use of a cloth filter.

The problems confronted in the fifth system were the following: first, the need of scraping the oil from the filter cloth and washing continuously the filter with hot solvent; and second, the continuous condensation of moisture on the chilling roll.

With sun-dried shreds the extraction was 92.2 per cent and with the oven-dried shreds, 94.1 per cent. The losses from the 400 ml. solvent used were 5.5 ml. and 7.7 ml. for the sun-dried and oven-dried shreds, respectively.

A number of extractions showed the efficiency of the system to be 71 per cent. Without considering the amount of solvent retained in the shreds and oil, an average of 307 ml. was recovered from the 400 ml. solvent used. The low amount of oil recovered was due to the high retention of oil by the system.

The oil obtained had a specific gravity of 0.9183 (30/30) and an acid value of 0.7061.

The effect of repeated use of the solvent on the substance in the miscella

The foreign non-oil substance increased with the repeated use of the solvent. More foreign non-oil substance solidified as the temperature was lowered. The percentage of oil extraction also decreased with the repeated use of the solvent.

Chemical nature of the white non-oil substance precipitating from alcohol solution at low temperature

According to Adriano, Manahan, and Barros (1929), shredded coconut endosperm has the following composition, in per cent:

Water	44.96	Proteins	1.22
Ash	1.06	Carbohydrates	2.27
Fats	32.92	Crude fiber	17.57

The proteins have been studied by Santos, 1920, and the carbohydrates by Caray, 1921. In his studies, Caray reported the presence of the following carbohydrates in copra meal: sucrose and raffinose, which are very slightly soluble in alcohol; galactose, which is slightly soluble; pentoses, glucose, and fructose, which are soluble; and cellulose, pentosans, starch, dextrin, and galactans, which are insoluble.

Tests made on the solution of the white precipitate showed the presence of reducing sugars in relatively large amounts. The Biuret and Xanthoproteic tests for proteins gave negative results.

SUMMARY

1. Five systems devised for studying the continuous extraction of coconut oil by means of ethyl alcohol could not be made to give a truly continuous system. The difficulties encountered in the oil-miscella separator operating below room temperature (18-20°C.) were due to the following:

(a) Condensation of moisture in the separator, thus diluting the solvent and preventing its effective repeated use;

(b) Precipitation in the separator of a white mass, identified as reducing sugar, which interfered with the proper separation of the oil from the miscella; and

(c) Unavailability of fairly large amounts of cooling liquid and lack of means for controlling its temperature.

2. A semicontinuous extraction with efficiency of 71 per cent was attained in the fifth system.

3. The continuous use of the solvent decreased the percentage of extraction but increased the amount of the non-oil substance (sugars) in the miscella.

4. A higher percentage of extraction was obtained from oven-dried samples than from sun-dried shreds.

LITERATURE CITED

Adriano, F. T., Mamerta Manahan, and Francisco Barros. 1929. The proximate chemical analysis of Philippine foods and feeding stuffs. Philippine Agriculturist **18**: 119–126.

Assoc. Off. Agric. Chem. 1945. Official and tentative methods of analysis. 6th ed. xii + 932 p. Washington, D.C.: Assoc. Off. Agric. Chem.

Bailey, A. 1945. Solvent extraction of oil. Industrial oil and fat products. xii+735 p. Baltimore: Waverly Press.

Browne, C. A. and F. W. Zerban. 1941. Physical and chemical methods of sugar analysis. 3rd ed. xiv + 1353 p. New York: John Wiley and Sons, Inc.

Carangal, Jr., Apolinario, and Julian Banzon. 1949. Studies on the solvent extraction of coconut oil with ethyl alcohol. Philippine Agriculturist **32**: 239–251.

Caray, Elias M. 1921. The chemical composition of copra meal with specific reference to the nature of its carbohydrates. Philippine Agriculturist **10**: 15–68.

Gregory, Thomas C. (editor) 1942. The condensed chemical dictionary. 3rd ed. 756 p. New York: Reinhold Publishing Company.

Santos, Francisco O. 1920. A biochemical study of copra meal. Philippine Jour. Sci. **16** (2): 181–189.

TABLE 1

Solvent recovery and percentage of extraction under the different experimental systems[a]

EXPERIMENTAL SYSTEM NUMBER	WEIGHT OF SAMPLE	TEMPERATURE		VOLUME OF SOLVENT			WEIGHT OF OIL	PERCENTAGE OF EXTRACTION	RATING AS A CONTINUOUS SYSTEM
		Extraction	Separation	Recovered from miscella	Recoverable from shreds and oil	Losses due to evaporation			
	grams	*°C.*	*°C.*	*ml.*	*ml.*	*ml.*	*grams*		
1	50	73—70	15—18	520.0	50.6	28.4	24.1	90.5	Poor
2	50	73—65	15—18	487.7	61.1	51.2	23.4	87.8	Poor
3	50	73—70	20—21	505.3	63.4	31.3	24.9	93.7	Poor
4	50	73—70	15—18	344.0	51.7	4.3	24.7	92.9	Poor
Sun-dried	50	73—70	15—18	344.0	51.2	4.8	24.5	92.2	Fair
Oven-dried	50	73—70	15—18	338.0	55.0	7.0	25.0	94.1	Fair

[a]All data presented are the averages of at least three replications. All calculations were based on the Soxhlet determination of oil content (53.2 per cent), taking into account the weight of alcohol retained in the oil (0.115 gram EtOH/gram oil.)

TABLE 2

Performance of the fifth experimental system with oven-dried sample

TRIAL NUMBER	WEIGHT OF SAMPLE	VOLUME OF SOLVENT		WEIGHT OF OIL RECOVERED	EXTRACTION EFFICIENCY [a]
		Used	Recovered from miscella		
	grams	*ml.*	*ml.*	*grams*	*per cent*
1	50	400	305	12	48
2	50	400	307	13	52
3	50	400	307	15	60
4	50	400	308	19	76
5	50	400	306	20	80
6	50	400	305	21	84
7	50	400	306	21	84
8	50	400	308	21	84
Average.....	50	400	307	17.8	71

[a]Obtained by dividing the weight of oil recovered by 25 grams oil per 50-gram sample, which is the average weight of oil extracted from the previous experiment (table 1).

TABLE 3

Effect of the continuous use of the solvent on the solidifying matter present in the solvent and percentages of extraction and solvent recovery[a]

NATURE OF SOLVENT	EXTRACTION	SOLVENT RECOVERY[b]	SOLIDIFYING MATTER					
			15°C.		14°C.		11°C.	
			Liquid	Solid	Liquid	Solid	Liquid	Solid
	per cent	*per cent*	*ml.*	*ml.*	*ml.*	*ml.*	*ml.*	*ml.*
Fresh.....	93.3	84.2	20	0	20	0	20	0
After first extraction.....	90.6	82.0	19	1	18	2	17	3
After second extraction....	80.4	88.4	18.3	1.7	17.3	2.7	16	4
After third extraction.....	72.1	88.6	18.3	1.7	16	4	15.3	4.7
After fourth extraction....	69.6	88.8	18	2	15	5	14	6
After fifth extraction.....	47.7	88.7	15.3	4.7	11.6	8.4	10	10
After sixth extraction.....	41.2	88.9	15	5	11	9	10	10

[a]Data presented are averages of at least three replications.

[b]Computed without taking into account solvent recoverable from oil and shreds.

THE INFLUENCE OF RAINFALL AND CULTURAL PRACTICES ON SOIL EROSION AND SURFACE RUNOFF[1]

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WITH THREE TEXT FIGURES

A study on the amount of soil and water losses was conducted in one of the lots of the Department of Animal Husbandry, College of Agriculture, Los Baños, Laguna, from September 15, 1949, to January 15, 1950, and from May 1, 1950, to September 15, 1950. The object of the study was to determine the amount of soil loss and surface runoff on Lipa clay loam, with a grade of 9.72 per cent, as influenced by the amount of total rainfall and by some cultural practices.

Procedure

After the area selected had been plowed and harrowed twice, 12 experimental plots, grouped into three lots of four plots each, were laid to determine water and soil losses under different amounts of rainfall and under various cultural practices. The plots, each 2 meters wide and 25 meters long, were separated from each other by 25-centimeter dividers made of galvanized iron sheets set 15 centimeters deep in the ground to prevent the rain falling on any plot from affecting the adjacent plots. The three lots were separated from each other by a vacant space 3 meters wide.

The water and soil lost from each plot were conveyed by plain galvanized-iron sheet funnels into their respective graduated 55-gallon receivers dug in at the lower end of each plot (fig. *1a*, *1b*, and *1c*). A shed was built over the canals and funnels to prevent direct rain water from entering into the receivers (fig. *2a* and *1d*).

The arrangement of the plots according to the cultural practices was randomly made as follows:

PLOT NUMBER	TREATMENT
1, 7, and 11	I. Planted to corn with rows made across the slope and cultivated to keep down the weeds to a minimum.
2, 4, and 8	II. Planted to corn with the rows made along the slope. Also cultivated.
3, 9, and 12	III. Uncultivated, sodded to natural vegetation.
5, 6, and 10	IV. No crop; fallowed and weeds removed by pulling.

[1]Experiment Station Contribution No. 1574. Prepared from the thesis entitled, "Preliminary Study of Soil Erosion and Surface Runoff as Influenced by Rainfall and Cultural Practices," presented by Raymundo E. Jovellanos for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, November, 1950; oonducted in the Department of Agricultural Engineering in collaboration with the Department of Soils under the direction of the senior authors.

All the plots planted to corn were treated on the second planting with ammonium sulfate at the rate of 250 kilograms a hectare. A 90-centimeter row spacing and a 20-centimeter hill spacing were used throughout the experiment. Before planting, the rows were hilled up to about 15 to 20

Fig. 1—A view of the layout of the experimental plots, showing the dividers and the shed over the canals. (*Photographed by Dr. Julian Banzon of the Photographic Division*).

centimeters high and 30 to 35 centimeters wide at the base. All plots were planted to corn twice during the course of the study without any change in the original layout of the rows.

After each rain, the water lost as surface runoff was measured and recorded. The amount of soil lost from the plots as a result of the runoff was determined by evaporating enough aliquot and then weighing the residue therefrom. The average weight multiplied by the total amount of runoff from the corresponding plots gave the total amount of soil loss for that particular rain.

The amount of precipitation falling on the experimental plots was measured with a standard Baltimore rain gauge (fig. 3) placed in the middle of one of the vacant spaces separating the plots.

RESULTS AND DISCUSSION

The average annual rainfall in the College from 1917 to 1938, as given in the *Handbook of Philippine Agriculture* (1939), was 2106.05 millimeters. The precipitation in any given year, however, may vary considerably from the average. The average monthly rainfall from 1917 to 1938 and the rainfall for each month during the period of the experiment are given in table 1. The total daily precipitation at the experimental plots when the study was conducted differed from the total daily precipitation recorded at the College

Weather Station,[2] which is about a kilometer distant from the place of the present study. The College Weather Station is using a Japanese-made rain gauge that gives the reading in millimeters, accurate to 0.10 millimeter,

Fig. 2.—A view of the lower ends of the plots showing: (a) canal, (b) collector or receiver, (c) funnel, and (d) shed over the funnel. (*Photographed by Dr. Julian Banzon of the Photographic Division*).

whereas the rain gauge in the experimental plots is American-made, reading in inches by means of the dipstick, accurate only to 0.01 inch (about 0.30 millimeter).

The total rainfall at the College in 1949 was 1560.7 millimeters, and the maximum monthly rainfall in June of the same year was 270.7 millimeters. From January to September 15, 1950, the highest monthly rainfall of 246.4 millimeters occurred in May. The weather records from 1917 to 1938 at the Agricultural College Weather Station show that the maximum monthly rainfall occurred from May to December, inclusive. This indicates the necessity of soil and water conservation methods on sloping lands for a greater part of the year.

Water losses

From September 15, 1949 to September 15, 1950, there were 220 days during which some rain fell at the College of Agriculture. Twenty-eight of these rains were sufficiently strong to cause runoff from one or more of the experimental plots. The amount of runoff losses for the nine-month period from September 15, 1949 to September 15, 1950 as influenced by the various cultural practices, was computed on the hectare basis.

[2]The authors wish to acknowledge the help extended by Mr. Clemente Juliano, Jr., observer at the College Weather Station, in placing at their disposal the weather records of the station.

Losses from uncropped soil

Runoff, with a large total loss of water, occurred in all 28 rains from the uncropped fallowed plots. The amount of loss ranged from 6.0 gallons on September 17, 1949, to 213.3 gallons on May 30, 1950. Since the data

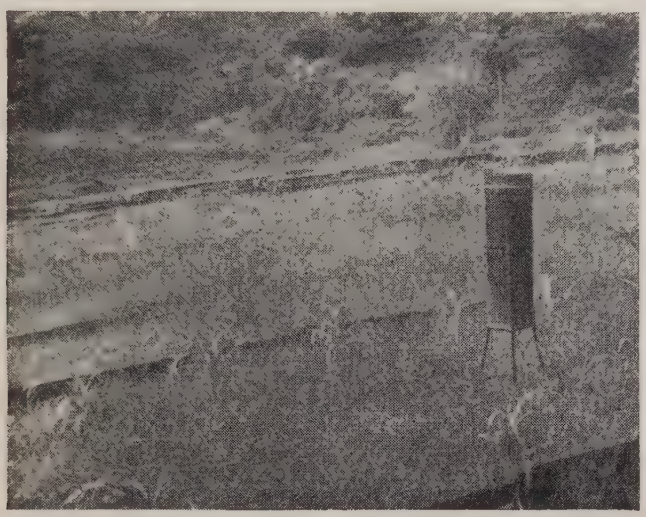

Fig. 3.—The rain gauge used in this study. (*Photographed by Dr. Julian Banzon of the Photographic Division*).

presented covered only a year of study, succeeding studies, which may be conducted over a longer period may produce somewhat different results.

The total runoff losses from the fallowed plots during the experiment was 1402.3 gallons (table 2), the highest losses being 364.3 gallons in November, 1949, and 325.8 gallons in May, 1950 (table 3).

Generally, runoff losses varied with the intensity of precipitation. From the data of the clean-fallow plots, however, other factors besides intensity may influence water losses. For example, on November 12, 1949, 64.6 gallons of runoff were lost after three hours of rain which had 26.2 millimeters of rainfall. Five hours earlier, rain fell for 20 hours and gave a rainfall of 40.6 millimeters, which caused only 77.6 gallons of runoff from the sample plots. Likewise, 64.3 gallons were lost from a rainfall of 25.4 millimeters, which fell in 175 minutes on June 2, 1950. In this case, however, it was 48 hours after the previous rainfall of 71.1 millimeters, with 13.9 millimeters of precipitation occurring within the period between the two rains. A rainfall of 25.9 millimeters, however, which fell for 90 minutes on the same plots on May 29, 1950 did not cause any runoff. Similar results obtained in August, 1950, and in September, 1950, are evidences that water losses are likely to occur on unprotected fields during rainfalls of low intensity if the soil is nearly or already saturated. This is in general agreement with the findings of Bartholomew, Carter, Hulbert, and Kapp (1939), Horner, McCall, and Bell (1944), and Lamb, Free, and Wilson (1944).

The writers conclude that these results, although obtained from barely a year's observation, emphasize the need for water conservation.

Effect of close-growing vegetation

The effect of close-growing vegetation on surface runoff and soil losses was studied on three of the 12 plots, uncultivated, and allowed to grow to natural vegetation consisting of the following:[3]

SCIENTIFIC NAMES	FAMILY
Cynodon dactylon (Linn.) Pers.	Gramineae
Tephrosia candida (Roxb.) DC.	Leguminosae
Synedrella nodiflora (Linn.) Gaertn.	Compositae
Cyperus rotundus Linn.	Cyperaceae
Calopogonium mucunoides Desv.	Leguminosae
Imperata cylindrica (Linn.) Beauv.	Gramineae
Corchorus acutangulus Lam.	Malvaceae
Mimosa pudica Linn.	Leguminosae
Euphorbia hirta Linn.	Euphorbiaceae
Phyllanthus niruri Linn.	Euphorbiaceae
Panicum miliaceum Linn.	Gramineae
Celosia argentea Linn.	Amaranthaceae

The most abundant of the weeds were *Cyperus rotundus* Linn. and *Calopogonium mucunoides* Desv. Of the 28 rains that caused surface runoff from the other plots, only 20 were able to cause some runoff from the plots sodded to natural vegetation. Most of the these losses occurred in the early part of the first and second experiments when the plots were not yet fully covered with weeds.

Vegetative covers, especially close-growing crops and grasses, have been reported by Moorhouse (1909), Stewart and Forsling (1931), Yoder (1936), Bartholomew, Carter, Hulbert, and Kapp (1939), Daniel, Elwell, and Cox (1943), Horner, McCall, and Bell (1944), and many others as effective for checking soil and water losses from sloping fields. Mamisao (1950) recommended the planting of "critical areas" with a thick canopy of vegetation, preferably grasses and legumes, for reducing soil and water losses.

The writers noted that the total water lost from the plots sodded to weeds for the whole period of the study was only 335.2 gallons as compared with a loss of 1,402.3 gallons from the clean-fallow plots (table 2). The big difference in water losses from the two types of plots, two opposite extremes of soil management, indicates the value of close-growing vegetation covers, especially grasses, on sloping land.

Effect of row direction

A comparison of the water and soil losses given in tables 2, 3, and 5 shows that in water and soil conservation, planting corn with the rows across the slope was next in effectiveness to planting close-growing vegetation. Knoblauch (1942) reported significant reductions in water losses by planting corn on the contour. The writers found that planting corn across the slope decreased water losses by one third to one half of the losses when corn was planted in rows along the slope.

[3]The scientific names of all vegetation found in the plots were determined by Dr. José R. Velasco, Assistant Professor, Department of Agricultural Botany.

The results given in tables 2 and 5 may not be applicable to general field conditions, owing to variables other than row direction. However, the advantages of planting across the slope for conserving water on sloping fields are pointed out.

Soil losses

The reduction of soil loss to the minimum is the most important object of soil conservation. Any method of soil management which effectively reduces loss of water from surface runoff will also reduce the amount of soil loss from the fields. Table 3 gives in kilograms the soil lost for every 1/200-hectare plot and table 5, the computed soil and water losses in a hectare.

Losses from fallowed plots

Plots in fallow served as check on the effectiveness of the other systems of management for the prevention of soil loss. For the nine-month period, the total amount of soil lost from the uncropped plots was 268.013 kilograms (tables 3 and 5). During the heavy rainfall period, May 15 to 30, 1950, a loss of 110.192 kilograms was recorded. During rains the runoff water from the uncropped plots appeared very much more turbid than the runoff water from the other plots, indicating the presence of more soil particles in suspension. The uncropped plots always lost a greater amount of soil than the plots where other forms of soil management were employed.

Effect of vegetative cover

The plots protected by a vegetative cover gave the lowest amount of soil erosion (tables 3 and 5). The results also show that as the vegetation became established, soil losses decreased. During the heavy rains of May 15 to May 30, 1950, the plots with vegetative cover lost only 4.423 kilograms of water-free soil, whereas the uncropped plots lost 110.192 kilograms. From May 30 to June 30, 1950, the uncropped plots lost 116.078 kilograms of soil, whereas the plots with vegetative protection lost only 4.615 kilograms. Close-growing crops and grasses were effective in minimizing soil losses. Field rats and other burrowing rodents and insects may increase soil losses from sloping fields by loosening the soil and placing it among the plants.

Effects of row direction

The soil losses were 24.238 kilograms from plots planted to corn with the rows across the slope and 150.587 kilograms from plot with the rows along the slope. Throughout the experiment, the amounts of soil lost were always higher from the plots with rows along the slope than from the plots with rows across the slope. The rows along the slope served as small canals through which the runoff water could pass, carrying with it more and more soil particles as it increased in velocity and volume. The rows across the slope, however, acted as barriers to the downward rush of the runoff water, and enabled more water to enter the soil profile.

Correlation

Table 4 gives the coefficients of correlation of the gross amount of rainfall with runoff and soil loss and those of surface runoff with soil loss.

By correlating the amount of rainfall with the amount of runoff, the following values for the coefficient (r) were obtained:

Treatment	I	+ 0.624
"	II	+ 0.728
"	III	+ 0.568
"	IV	+ 0.760

All the correlation coefficients between rainfall and runoff were significant. This shows that the amount of rainfall directly affected the amount of surface runoff from the experimental plots. Stewart and Forsling (1931), Yoder (1936), Bartholomew, Carter, Hulbert, and Kapp (1939), Daniel, Elwell, and Cox (1943), and Horner, McCall, and Bell (1944) reported the effectiveness of vegetative cover for reducing water and soil losses. The writers found that treatment III had the least value of coefficient, indicating that sodding is effective for reducing surface runoff from the plots. Baver (1935), Bennet (1936), Wilson and Neal (1938), Gustafson (1940), Knoblauch (1942), and Tedrow (1945) reported reduced water and soil losses from contour tillage on sloping fields. The writers noted that treatment I plots in corn with rows across the slope had less runoff than treatment II plots with rows along the slope.

The coefficients of correlation between the amount of rainfall and the amount of soil loss were as follows:

Treatment	I	+ 0.601
"	II	+ 0.608
"	III	+ 0.723
"	IV	+ 0.632

These values are significant and they show that the amount of rainfall directly affected the amount of soil loss.

When the amount of surface runoff was correlated with the amount of soil loss, the values of the coefficient (r) obtained were as follows:

Treatment	I	+ 0.687
"	II	+ 0.897
"	III	+ 0.921
"	IV	+ 0.913

All the above values were significant. The amount of surface runoff was closely correlated with the amount of soil loss. As the amount of runoff increased, the amount of soil loss also increased. In treatment III with the highest coefficient of correlation there was a closer relation of the amount of runoff with the amount of soil loss in the sodded plots than in the others.

SUMMARY

1. The total water losses as surface runoff, under the conditions of the experiment, were 420.2 gallons from the plots planted to corn with rows across the slope, 1,080.6 gallons from the plots with corn in rows along the slope, 335.2 gallons from the plots allowed to natural vegetation, and 1,402.3 gallons from the fallowed plots. The water lost from the plots with corn in rows along the slope was 2.57 times that from the plots planted to corn in rows across the slope, whereas the plots in fallow lost 4.18 times that of the sodded plots.

2. The plots with corn rows across the slope lost a total of 24.238 kilograms of soil; the plots planted with corn in rows along the slope, 150.587

kilograms; those left to natural vegetation, 11.834 kilograms; and the plots in fallow, 268.013 kilograms. The soil lost from the plots with corn in rows along the slope was 6.21 times as much as from the plots with corn in rows across the slope. The plots in fallow lost 22.64 times as much as the sodded plots.

3. In general, water and soil losses increased as the rainfall increased. The correlation between the amount of runoff with the amount of soil loss was also significant. Generally, an increase in the amount of surface runoff was accompanied by an increase in the amount of soil lost.

4. Planting corn across the slope in lands with 9.72 per cent grade was effective in reducing water and soil losses. Natural vegetation or sod was better than clean fallow for minimizing water and soil losses from lands with a 9.72 per cent grade.

LITERATURE CITED

Bartholomew, R. P., Deane G. Carter, W. C. Hulbert, and L. G. Kapp. 1939. Influence of rainfall, cropping, and cultural methods on soil and water losses. Arkansas Agric. Exper. Sta. Bull. 380: 1–48.

Baver, L. D. 1935. Soil erosion in Missouri. Missouri Agric. Exper. Sta. Bull. 349: 3–64.

Bennet, H. H. 1936. Conservation farming practices and flood control. U. S. Dept. Agr. Misc. Pub. No. 253: 1–16.

Daniel, Harley A., Harrey M. Elwell, and Maurice B. Cox. 1943. Investigations in erosion control and reclamation of eroded land at the Red Plains Conservation Experiment Station, Guthrie, Oklahoma. 1930–40. U. S. Dept. Agri. Tech. Bull. 837: 1–94.

Gustafson, A. F. 1944. The control of soil erosion in New York. Cornell Univ. Ext. Bull. 438: 3–42. (Revised)

Horner, Glenn M., A. G. McCall, and F. G. Bell. 1944. Investigations in erosion control and the reclamation of eroded land at the Palouse Conservation Experiment Station, Pullman, Wash. 1931–42. U.S. Dept. of Agr. Tech. Bull. 860: 1–83.

Knoblauch, H. C. 1942. Contour tillage of corn under New Jersey conditions in relation to soil and water conservation, crop yields, and various soil properties. Jour. Amer. Soc. Agron. **34**: 263–269.

Lamb, Jr., J., G. R. Free, and H. H. Wilson. 1944. The seasonal occurrence of soil erosion in New York as related to rainfall intensities. Jour. Amer. Soc. Agron. **36**: 37–45.

Mamisao, J. P. 1950. Soil conservation hints to our farmers. Jour. Soil Sci. Soc., Philippines. **2**: 136–137.

Moorhouse, L. A. 1909. Some soil problems in Oklahoma. Proc. Amer. Soc. Agron. **1**: 234–236.

Stewart, George, and C. L. Forsling. 1931. Surface runoff and erosion in relation to soil and plant cover on high grazing land of Central Utah. Jour. Amer. Soc. Agron. **23**: 815–832.

Tedrow, N. P. 1945. Save the soil. Connecticut Ext. Ser. Bull. 370: 3–13.

Wilson, J. B., and J. N. Neal. 1938. Terracing and related soil conservation practices for Alabama. Alabama Polytech. Insti. Ext. Cir. 165: 2–24.

Yoder, Robert E. 1936. A direct method of aggregate analysis of soils and a study of the physical nature of erosion losses. Jour. Amer. Soc. Agron. **28**: 337–351.

TABLE 1

Monthly rainfall at the College of Agriculture, U. P., at College, Laguna, (September 15, 1949 to September 15, 1950) compared with the monthly average for 22 years

MONTH	MONTHLY PRECIPITATION		
	1949	1950	Years of Record Average 1917–1938[a]
	mm.	*mm.*	*mm.*
January	—	93.3	60.6
February	—	44.8	27.8
March	—	714.0	31.6
April	—	31.0	44.9
May	—	246.4	168.8
June	—	174.6	203.3
July	—	117.6	320.6
August	—	176.8	279.6
September 1–15	—	71.3	
September 15–30	93.8	—	261.0
October	135.7	—	261.0
November	250.7	—	295.5
December	175.6	—	115.3

[a]Data for 1917–1938 taken from the *Handbook of Philippine Agriculture*

TABLE 2

Total monthly precipitation and surface runoff losses from experimental plots of Lipa clay loam with a grade of 9.72 per cent (September 15, 1949 to September 15, 1950)

MONTH	PRECIPITATION	TOTAL SURFACE RUNOFF IN GALLONS[a]			
		Treatment I[b]	Treatment II	Treatment III	Treatment IV
1949	*mm.*				
September 15–30	83.1	12.3	39.2	29.5	45.9
October	165.8	37.2	84.9	52.3	109.5
November	283.6	118.5	287.4	87.5	364.4
December	189.4	31.6	92.9	13.6	155.6
January, 1950	83.1	trace[c]	6.6	trace	12.3
May	255.1	78.9	250.8	84.2	325.8
June	152.2	32.9	73.6	16.9	99.3
July	139.5	23.9	64.6	10.3	82.6
August	152.1	63.6	131.3	30.6	157.6
September 1–15	78.0	21.3	49.3	13.3	70.3
Total	1,581.9	420.2	1,080.6	335.2	1,402.3

[a]Average of three 1/200-hectare plots.

[b]Treatment I consisted of plots 1, 7, and 11 planted to corn, with rows across the slope.
Treatment II consisted of plots 2, 4, and 8 planted to corn, with rows along the slope.
Treatment III consisted of plots 3, 9, and 12 uncultivated and sodded to natural vegetation.
Treatment IV consisted of plots 5, 6, and 10 fallowed; weeds removed by pulling.

[c]Indicates no measurable surface runoff.

TABLE 3

Total monthly precipitation and soil losses from experimental plots of Lipa clay loam with a grade of 9.72 per cent (September 15, 1949 to September 15, 1950)

MONTH	PRECIPITATION	TOTAL SOIL LOSSES IN KILOGRAMS[a]			
		Treatment I[b]	Treatment II	Treatment III	Treatment IV
1949	*mm*				
September 15–30	83.1	0.187	1.298	0.387	2.183
October	165.8	0.717	5.529	0.728	8.567
November	283.6	7.763	47.533	5.092	80.459
December	189.4	0.517	7.173	0.108	15.579
1950					
January	83.1	trace[c]	0.015	trace	0.097
May	255.1	11.478	69.306	4.423	112.281
June	152.2	0.886	4.196	0.255	7.245
July	139.5	0.465	4.156	0.102	6.566
August	152.1	1.870	7.331	0.514	30.626
September 1–15	78.0	0.355	2.050	0.125	3.410
Total	1,581.9	24.238	150.587	11.854	268.013

[a]Average of three 1/200-hectare plots.

[b]Treatment I consisted of plots 1, 7, and 11 planted to corn, with rows across the slope.
Treatment II consisted of plots 2, 4, and 8 planted to corn, with rows along the slope.
Treatment III consisted of plots 3, 9, and 12 cultivated and sodded to natural vegetation.
Treatment IV consisted of plots 5, 6, and 10 fallowed; weeds were removed by pulling.

[c]Indicates no measurable soil loss.

TABLE 4

Correlation of amount of rainfall with runoff; amount of rainfall with soil loss and runoff with soil loss[a]

RELATIONSHIP	COEFFICIENT OF CORRELATION (R)	t-VALUE			REMARKS
		.05	.01	Computed	
Amount of rainfall with runoff for:					
Treatment 1[b]	+ 0.624	2.056	2.779	4.071	significant
Treatment 2[c]	+ 0.728	2.056	2.779	5.410	
Treatment 3[d]	+ 0.568	2.056	2.779	3.479	
Treatment 4[e]	+ 0.760	2.056	2.779	6.096	
Amount of rainfall with soil loss for:					
Treatment 1	+ 0.601	2.056	2.779	3.864	significant
Treatment 2	+ 0.608	2.056	2.779	3.904	
Treatment 3	+ 0.723	2.056	2.779	5.336	
Treatment 4	+ 0.632	2.056	2.779	4.160	
Surface runoff with soil loss for:					
Treatment 1	+ 0.687	2.056	2.779	4.820	significant
Treatment 2	+ 0.897	2.056	2.779	10.365	
Treatment 3	+ 0.021	2.056	2.779	12.368	
Treatment 4	+ 0.913	2.056	2.779	11.442	

[a] With 26 degrees of freedom

[b] Planted to corn with furrows across the slope.

[c] Planted to corn with furrows along the slope.

[d] Uncultivated, sodded to natural vegetation.

[e] Not cropped, fallowed with weeds removed.

TABLE 5

Computed soil and water losses to the hectare for the 9-month period (September 15, 1949 to September 15, 1950) based on data obtained from the experimental plots

PLOT NUMBER	TREATMENT	TOTAL WATER LOSS	TOTAL SOIL LOSS	
		gal.	*kg.*	*tons*
1, 7, & 11	Planted to corn with rows across the slope	84,040.0	4,847.6	4.8476
2, 4, & 8	Planted to corn with rows along the slope	216,120.0	30,117.4	30.1174
3, 9, & 12	Uncultivated, sodded to natural vegetation	67,040.0	2,366.3	2.3668
5, 6, & 10	No crop; fallowed; weeds removed by pulling	280,460.0	53,602.6	53.6026

THE CAPACITY OF PHILIPPINE STEERS FOR PLOWING[1]

CRISPULO Q. QUIBIN

Farmers in the Philippines depend largely on the native plow and work animals, commonly the native oxen to till the soil. The number of cattle in 1945 was 559,970, of which 145,592 were work cattle[2],[3]. It is not known, however, how much work the native cattle can do for plowing purposes. Catambay[4] found that in the College of Agriculture at Los Baños, Laguna, the mean number of hours it took a work bullock to plow a hectare of land using the native plow and plowing an average depth of 11 centimeters at an average speed ranging from 1.30 to 2 kilometers per hour, was 63.91 ∓ 0.45 hours. A study of the native steers for plowing purposes was made in the Department of Animal Husbandry from December, 1948, to November, 1949.

THE ANIMALS USED

Six native work bullocks of the Department of Animal Husbandry were used in the study. Their ages, heights, weights, and condition are tabulated below.

NAME AND HERD NUMBER OF ANIMALS	APPROXIMATE AGE *years*	HEIGHT *cm.*	WEIGHT *kg.*	CONDITION
Steady, 2	13	133	482	Medium
Makisig, 3	10	122	387	Medium
Bilukao, 6	10	133	519	Medium
Kalejon, 9	10	132	505	Medium
Kamal, 10	7	130	462	Medium
Kalo, 11	7	124	400	Medium
Mean	9.50	129.0	459.16	

PROCEDURE OF THE EXPERIMENT

A native plow, with 4 inches (10.16 centimeters) width of cut, was used. A level land of clay loam with an average moisture content of 29.98 per cent in the first plowing and 30.26 per cent[5] in the replowing, was used. In the first plowing, the land was covered with grasses, such as *Paspalum conjugatum* Berg., *Cynodon dactylon* Pers., *Digitaria corymbosa* Merr., *Cyperus rotundus* Tag., and the legume *Centrosema pubescens* Benth. Santos[6]

[1]Experiment Station Contribution No. 1575. Thesis presented for graduation with the degree of Bachelor of Science in Agriculture, April, 1950. Prepared in the Department of Animal Husbandry under the direction of Professor Valente Villegas.

[2]ANONYMOUS. 1941. Census of the Philippines. 1939. Vol. II: 1739 p. Manila: Bureau of Printing.

[3]ANONYMOUS. 1947. Yearbook of Philippine Statistics. 1946. 499 p. Manila: Bureau of Printing.

[4]CATAMBAY, A. B. 1931. Plows and plowing: IV. Cost of plowing with different plowing outfits. Philippine Agriculturist **20**: 410–420.

[5]Determination by the Experiment Station of the College of Agriculture.

[6]SANTOS, G. P. Draft test of native lowland and upland wooden plows. (Thesis presented for graduation with the degree of Bachelor of Science in Agriculture, 1948. Unpublished.)

reported that a soil moisture content of 31.26 per cent in the first plowing gave a draft of 417.64 grams for each square centimeter (5.93 pounds for each square inch); at 28.35 per cent moisture, the draft was 317.47 grams for each square centimeter (4.51 pounds for each square inch); whereas in replowing, a soil moisture content of 28.66 per cent gave a draft of 269.89 grams for each square centimeter (3.83 pounds for each square inch). When the moisture content of the soil was 26.82 per cent, the draft was 262.84 grams for each square centimeter (3.73 pounds for each square inch). This author also stated that thick growth of weeds slowed down the animal and increased the draft.

Fifteen trials were made with each animal, six in the first plowing and nine in the replowing. Each trial, which was done only when the weather was favorable, lasted for six hours. The strip method, locally known as *digla*, was followed. Only one plowman was hired throughout the work. Plowing was done from 7:00 o'clock to 11:00 o'clock in the morning, and from 1:00 o'clock to 3:00 o'clock in the afternoon.

The animal was allowed to drink before it started to plow. The average depth of the first plowing was 10 centimeters and that of replowing, 12.6 centimeters. The plowed land was harrowed well before any replowing. During plowing, the speed and number of strides of the animal were observed and recorded; the stopwatch and the hand tally were used for these purposes. The hitch was adjusted such that each animal could maintain a more or less uniform depth of plowing during all trials.

RESULTS AND DISCUSSION

The area plowed

Table 1 shows that the area plowed by the work bullocks in the first plowing and in the replowing varied. Bilukao, the tallest and heaviest among the six animals, plowed the biggest mean daily areas of 1,666.66∓90.83 square meters in the first plowing and 2,519.33∓108.53 square meters in the replowing. Steady, of the same height as Bilukao but third in weight, was second in performance, with a mean area of 1,596.33∓109.66 square meters daily in the first plowing and 2,402.00∓88.99 square meters in the replowing. Makisig, the smallest and the lightest of the six animals, plowed the least in the first plowing, with a mean area of 1,123.00∓61.98 square meters daily. In replowing, however, Makisig plowed a mean area of 1,793.77∓97.32 square meters daily, whereas Kalo, though slightly taller and heavier than Makisig, plowed only 1,561.77∓88.32 square meters. The figures show that the two smallest and lightest animals were the poorest in performance. The performance of all six steers considered, the mean areas plowed were 1,362.74∓92.14 square meters in the first plowing and 1,999.79 ∓153.39 square meters in the replowing. The difference was highly significant. Obviously, the difference was due to the draft which was much heavier in the first plowing than in the replowing.

Period from the start of plowing to the time the animals began to pant, and area plowed

Table 2 shows that in the morning the animals panted after a period ranging from 93.01∓11.14 to 119.00∓17.88 minutes from the start of plowing. Kalo, a slow-walking animal, was the last to pant. It panted

after a mean period of 119.00∓17.88 minutes. On the other hand, Steady, an active and fast-walking animal, was the first to pant, within a mean period of 93.01∓11.14 minutes. The mean period for all the animals was 105.87∓4.71 minutes. All the animals panted earlier in the afternoon than in the morning. The higher air temperature in the afternoon was obviously the principal reason for the effect upon the animals. The periods in the afternoon varied from 86.77∓11.17 to 105.00∓5.40 minutes. Kalejon, a slow-moving animal, was the last to pant in the group, the mean period being 105.00∓5.40 minutes. Bilukao, the fastest-moving bullock, panted first, with a mean period of 89.23∓7.45 minutes. The mean period for all the animals was 94.89∓3.24 minutes. The period from the start of plowing to the time when animals started to pant was slightly longer in the morning than in the afternoon, but the difference was insignificant.

Table 2 shows that the mean area plowed in the morning was bigger than that plowed in the afternoon, but the difference was insignificant. In the morning, the animals plowed a mean area of from 360.51∓26.23 to 531.00.∓36.00 square meters. Bilukao plowed the widest area, 531.00∓36.00 square meters; Makisig plowed the least, 360.51∓26.23 square meters. The mean area for all bullocks was 423.29∓28.09 square meters. In the afternoon, the mean area plowed by the animals ranged from 302.33∓34.74 to 421.33∓25.08 square meters. Bilukao again covered the widest area, 421.33∓25.08 square meters and Makisig the least, 302.33∓34.74 square meters. The mean for all bullocks in the afternoon was 374.07∓18.11 square meters.

Table 3 shows that in the replowing, the periods from the start of plowing to the time the animals began to pant were longer, 91.11∓7.77 to 109.41∓5.48 minutes in the morning and 87.83∓5.55 to 101.33∓7.56 minutes in the afternoon. Kalejon, with a mean of 109.41∓5.48 minutes, panted the latest in the morning; Bilukao, with a mean of 91.11∓7.77 minutes, panted the earliest. The means for all the animals were 100.06∓2.56 minutes in the morning and 94.80∓2.34 minutes in the afternoon. Again, in the afternoon, the last to pant was Kalejon (101.33∓5.55 minutes) and Steady, the first (87.83∓5.55 minutes). The mean for the animals before panting in the morning was slightly bigger than that of the afternoon, but there was no marked difference between the means during the first plowing and the replowing.

Table 3 shows marked increase in area in the replowing over that in the first plowing. The area plowed was bigger in the morning, 467.67∓34.77 to 734.18∓65.73 square meters, or a mean of 591.21∓38.37, than in the afternoon (table 3). Steady plowed the widest area, 734.18∓65.73 square meters; Kalo, the least, 467.67∓34.77. In the afternoon, the animals plowed a little smaller average area than in the morning, 459.71∓38.83 to 639.89∓62.88 square meters. Bilukao plowed the largest mean area, 639.89∓62.88 square meters; Steady second, 611.55∓46.33 square meters; Makisig third, 498.41∓54.37; and Kalo last, 459.71∓38.83. The mean area for all the animals was 549.74∓29.19 square meters.

Time consumed by work bullocks to travel 100 meters during plowing

The time needed by the work bullocks to travel 100 meters in the morning is shown in table 4. It took Bilukao 2.02∓0.06 minutes to travel

the first 100 meters in the first plowing and Makisig, 4.02∓0.23 minutes. The mean for all the animals was 3.21∓0.38 minutes. In the replowing, the mean time ranged from 1.66∓0.07 minutes for Bilukao to 3.44∓0.24 minutes for Kalo. The mean for all animals was 2.53∓0.30 minutes. After two hours, all the animals gradually required more time to cover the distance, from 2.32∓0.04 minutes (Bilukao) to 4.16∓0.37 minutes (Kalo) in the first plowing, and from 2.12∓0.15 minutes to 3.72∓0.22 minutes in the replowing. After two hours, all animals consumed 3.40∓0.35 minutes in the first plowing and 2.97∓0.30 minutes in the replowing. With the further slowing down to the end of the fourth hour, it took the animals from 2.62∓0.08 minutes (Bilukao) to travel 100 meters to 4.32∓0.18 minutes (Makisig) in the first plowing; the mean for all the animals was 3.64∓0.31 minutes. In the replowing, the period ranged from 2.30∓0.14 minutes (Bilukao) to 3.87∓0.27 minutes (Kalo); the mean for all animals was 3.16∓0.28 minutes. Thus, it seems that although the mean time for traveling 100 meters at two-hour intervals gradually increased in plowing and in replowing, the increase in the mean period was not significant. The difference between the mean periods, however, was highly significant in favor of the first plowing. Table 4 shows that Bilukao, the fastest in both operations, covered the first 100 meters at the start of plowing in 2.02∓0.06 minutes and at the end of the fourth hour in 2.62∓0.08 minutes; whereas in replowing, it required 1.66∓0.07 minutes at the beginning and 2.30∓0.14 minutes at the end of the fourth hour. Steady, second to Bilukao, made the first 100 meters in 2.10∓0.06 minutes in the first plowing and in 2.75∓0.15 minutes at the end of the fourth hour. In the replowing, it made the first 100 meters in 1.74∓0.16 minutes and at the end of the fourth hour in 2.34∓0.09 minutes. Makisig, which made the first 100 meters in 4.02∓0.23 minutes and in 4.32∓0.18 minutes after four hours in the first plowing, covered the same distance in 3.20∓0.27 minutes at the start and in 3.80∓0.41 minutes after four hours in the replowing. Kalo, the slowest, required 3.97∓0.24 minutes for the first 100 meters and 4.30∓0.13 minutes after four hours in the first plowing, and 3.44∓0.24 minutes for the first 100 meters and 3.87∓0.27 at the end of four hours in the replowing.

The time consumed by the work bullocks to travel 100 meters in the first plowing in the afternoon ranged from 2.05∓0.05 to 4.15∓0.45 minutes (mean, 3.12∓0.39); in replowing, from 1.83∓0.07 to 3.18∓0.10 minutes (mean, 2.62∓0.25). After two hours, the mean time for each animal to travel 100 meters ranged from 2.30∓0.10 to 4.35∓0.45 minutes (mean, 3.42∓0.34) in the first plowing and from 2.08∓0.11 to 3.45∓0.09 minutes (mean, 2.90∓0.23) in the replowing. After four hours their means varied from 2.50∓0.12 to 4.45∓0.35 minutes (mean, 3.58∓0.33) in the first plowing and from 2.23∓0.10 to 3.60∓0.13 minutes (mean, 3.05∓0.24) in the replowing. The mean in the time required to travel 100 meters in the first plowing and in the replowing gradually increased after intervals of two hours. The difference, though insignificant, was longer in the first plowing than in the replowing. Bilukao was consistently the fastest; Steady, second; Makisig and Kalo, the slowest; and Kamal and Kalejon, intermediate (table 3). The rates of speed in the morning and in the afternoon were about the same (tables 4 and 5).

Number of strides work bullocks needed to travel 100 meters

Table 6 shows that Bilukao, one of the biggest of the six animals and the fastest, made the least average number of strides required to cover 100 meters at intervals of two hours in the morning. Kalo, one of the smallest and a slow-moving animal, made the most strides. Bilukao made means from 161.00∓7.05 to 170.25∓7.10 strides per 100 meters in the first plowing and 149.66∓4.13 to 159.66∓5.29 strides to the end of four hours in the replowing; Kalo, from 214.00∓12.40 to 220.00∓15.36 strides per 100 meters from the start to the end of four hours in the first plowing and 192.00∓4.50 to 197.20∓4.17 in the replowing. The means for all the animals were 191.44∓8.83 in the first 100 meters and 166.57∓6.26 in the replowing; after two hours, 195.13∓8.83 in the first plowing and 179.27∓6.11 in the replowing; and at the end of four hours, 198.19∓8.54 in the first plowing and 173.02∓6.69 in the replowing. There was a gradual increase in the number of strides made by the animals at intervals of two hours in the first plowing and in the replowing. Although the increase was insignificant, the difference between the means of number of strides was higher in the first plowing than in the second.

The number of strides in the afternoon at two-hour intervals showed little differences from those made in the morning (table 7). The mean during the first plowing was 188.47∓7.64; in the replowing, 170.45∓6.56. After two hours, the means were 191.04∓7.62 in the first plowing and 173.23∓6.62 in the replowing. At the end of the fourth hour the means were 192.84∓7.64 in the first plowing and 175.53∓6.87 in the replowing.

SUMMARY

1. Although the bigger animals panted earlier than the smaller ones, the former plowed larger areas before they started to pant.

2. There was no significant difference in the time it took the animals to travel 100 meters at two-hour intervals. The animals required significantly longer time to walk 100 meters in the first plowing than in the replowing; there was no difference in the morning and in the afternoon.

3. The work bullocks made more strides in the first plowing than in the replowing. With the load constant, they shortened their strides as they got tired. The bigger and faster the animals, the fewer the strides made. There was no significant difference in the number of strides during the day's work.

TABLE 1

Area plowed by work bullocks, based on 6-hour working day

NAME OF ANIMALS	FIRST PLOWING	REPLOWING
	Square meters	*Square meters*
Steady	1,596.33∓109.66	2,402.00∓ 88.99
Makisig	1,123.00∓ 61.98	1,793.77∓ 97.32
Bilukao	1,666.66∓ 90.83	2,519.33∓108.53
Kalejon	1,170.50∓ 74.00	1,890.11∓ 68.64
Kamal	1,485.83∓ 70.18	1,831.77∓ 93.32
Kalo	1,134.16∓ 81.50	1,561.77∓ 88.32
Mean	1,362.74∓ 92.14	1,999.79∓153.39

TABLE 2

Period and area plowed by work bullocks from the start of plowing to the time animals began to pant during first plowing

NAME OF ANIMALS	PERIOD		A R E A	
	Morning	Afternoon	Morning	Afternoon
	minutes	*minutes*	*square meters*	*square meters*
Steady	93.01∓11.14	89.28∓ 9.21	485.81∓63.45	420.68∓74.92
Makisig	102.53∓11.80	95.00∓ 9.00	360.51∓26.23	302.33∓34.74
Bilukao	108.00∓10.12	89.23∓ 7.45	531.00∓36.00	421.33∓25.08
Kalejon	118.88∓17.63	105.00∓ 5.40	403.27∓51.00	357.77∓37.51
Kamal	93.82∓10.25	86.77∓11.17	382.33∓27.81	373.80∓31.45
Kalo	119.00∓17.88	104.06∓ 8.88	376.87∓38.91	368.54∓46.60
Mean	105.87∓ 4.71	94.89∓ 3.24	423.29∓28.09	374.07∓18.11

TABLE 3

Period and area plowed by work bullocks from start of plowing to the time animals began to pant during replowing

NAME OF ANIMALS	PERIOD		A R E A	
	Morning	Afternoon	Morning	Afternoon
	minutes	*minutes*	*square meters*	*square meters*
Steady	100.00∓ 9.79	87.83∓5.55	734.18∓65.73	611.55∓46.33
Makisig	97.51∓ 6.48	96.13∓5.82	527.57∓40.27	498.41∓54.37
Bilukao	91.11∓ 7.77	89.43∓6.54	644.57∓51.82	639.89∓62.88
Kalejon	109.41∓ 5.48	101.33∓7.56	614.43∓34.05	582.08∓47.48
Kamal	97.93∓14.63	93.00∓9.77	558.88∓50.82	506.83∓61.11
Kalo	104.43∓ 4.22	101.11∓5.67	467.67∓34.77	459.71∓38.83
Mean	100.06∓ 2.56	94.80∓2.34	591.21∓38.37	549.74∓29.19

TABLE 4

Time consumed by work bullocks to travel 100 meters at different periods in the morning

NAME OF ANIMALS	PERIOD					
	Initial		After 2 hours		After 4 hours	
	First plowing	Replowing	First plowing	Replowing	First plowing	Replowing
	minutes	*minutes*	*minutes*	*minutes*	*minutes*	*minutes*
Steady.....	2.10∓0.06	1.74∓0.16	2.35∓0.05	2.14∓0.12	2.75∓0.15	2.34∓0.09
Makisig.....	4.02∓0.23	3.20∓0.27	4.15∓0.20	3.54∓0.35	4.32∓0.18	3.80∓0.41
Bilukao.....	2.02∓0.06	1.66∓0.07	2.32∓0.04	2.12∓0.15	2.62∓0.08	2.30∓0.14
Kalejon.....	3.93∓0.41	2.43∓0.12	3.96∓0.48	3.03∓0.06	4.20∓0.37	3.23∓0.08
Kamal.....	3.25∓0.33	2.75∓0.05	3.47∓0.31	3.21∓0.05	3.70∓0.03	3.47∓0.10
Kalo.....	3.97∓0.24	3.44∓0.24	4.16∓0.37	3.72∓0.22	4.30∓0.13	3.87∓0.27
Mean.....	3.21∓0.38	2.53∓0.30	3.40∓0.35	2.97∓0.30	3.64∓0.31	3.16∓0.28

TABLE 5

Time consumed by work bullocks to travel 100 meters at different periods in the afternoon

NAME OF ANIMALS	PERIOD					
	Initial		After 2 hours		After 4 hours	
	First plowing	Replowing	First plowing	Replowing	First plowing	Replowing
	minutes	*minutes*	*minutes*	*minutes*	*minutes*	*minutes*
Steady.....	2.35∓0.15	2.05∓0.11	2.55∓0.11	2.40∓0.10	2.68∓0.08	2.52∓0.13
Makisig.....	4.15∓0.45	3.11∓0.26	4.35∓0.45	3.36∓0.24	4.45∓0.35	3.55∓0.22
Bilukao.....	2.05∓0.05	1.83∓0.07	2.30∓0.10	2.08∓0.11	2.50∓0.12	2.23∓0.10
Kalejon.....	3.90∓0.25	2.88∓0.21	4.10∓0.23	2.98∓0.14	4.30∓0.34	3.15∓0.13
Kamal.....	2.85∓0.35	2.72∓0.16	3.40∓0.30	3.18∓0.14	3.60∓0.30	3.28∓0.15
Kalo.....	3.45∓0.05	3.18∓0.10	3.85∓0.05	3.45∓0.09	4.00∓0.10	3.60∓0.13
Mean.....	3.12∓0.39	2.62∓0.25	3.42∓0.34	2.90∓0.23	3.58∓0.33	3.05∓0.24

TABLE 6

Number of strides of work bullocks made to travel a distance of 100 meters at different periods in the morning

NAME OF ANIMALS	PERIOD					
	Initial		After 2 hours		After 4 hours	
	First plowing	Replowing	First plowing	Replowing	First plowing	Replowing
Steady	170.50∓13.50	151.80∓ 4.90	173.50∓13.50	155.80∓ 5.50	175.50∓10.20	157.40∓ 5.20
Makisig	212.25∓16.54	169.00∓14.31	216.25∓17.52	174.00∓13.70	217.50∓16.68	174.88∓12.84
Bilukao	161.00∓ 7.05	149.66∓ 4.13	165.25∓ 8.83	154.33∓ 3.92	170.25∓ 7.10	159.66∓ 5.29
Kalejon	194.66∓11.93	171.00∓ 2.60	199.33∓12.71	174.33∓ 1.99	203.66∓11.33	176.00∓ 1.90
Kamal	196.25∓13.26	166.00∓ 3.00	199.00∓13.09	168.00∓ 2.00	202.25∓12.76	173.00∓ 1.00
Kalo	214.00∓12.40	192.00∓ 4.50	217.50∓16.04	195.20∓ 4.20	220.00∓15.36	197.20∓ 4.17
Mean	191.44∓ 8.83	166.57∓ 6.26	195.13∓ 8.83	179.27∓ 6.11	198.19∓ 8.54	173.02∓ 5.69

TABLE 7

Number of strides work bullocks made to travel a distance of 100 meters at different periods in the afternoon

NAME OF ANIMALS	PERIOD					
	Initial		After 2 hours		After 4 hours	
	First plowing	Replowing	First plowing	Replowing	First plowing	Replowing
Steady	170.00∓ 4.30	152.50∓ 3.50	172.25∓4.64	154.75∓ 3.60	174.75∓ 3.70	155.75∓ 3.09
Makisig	200.50∓10.01	187.50∓10.65	202.00∓8.00	190.83∓11.22	204.00∓ 9.00	192.28∓11.36
Bilukao	163.00∓ 3.00	152.66∓ 3.07	166.00∓2.00	156.83∓ 4.53	167.50∓ 1.50	157.05∓ 2.85
Kalejon	190.33∓ 6.83	169.16∓ 5.02	193.00∓7.50	171.16∓ 5.12	193.33∓ 4.25	172.66∓ 5.01
Kamal	194.50∓ 5.50	171.42∓ 4.38	197.50∓5.50	172.85∓ 3.74	200.00∓ 4.00	180.71∓ 4.19
Kalo	212.50∓10.03	189.50∓ 6.10	215.50∓8.50	193.00∓ 6.20	217.50∓10.50	194.75∓ 6.43
Mean	188.47∓ 7.64	170.45∓ 6.56	191.04∓7.62	173.23∓ 6.62	192.84∓ 7.64	175.53∓ 6.87

EFFECTS OF EXTRA NIGHT FEEDING ON THE RATE OF GROWTH OF MALE DUCKLINGS[1]

EUGENIO A. JONGO

Fronda[2] (1929) reported that it is a common practice among duck raisers along the shores of Laguna de Bay to give their ducklings extra feedings at night. A kerosene lantern is used to supply light to enable the birds to see their feed. These duck raisers claim that this practice can reduce the normal maturity period to about four and one-half months. To determine the influence of an extra night feeding on the rate of growth of male ducklings and on the economic aspect of green duck production, a study was undertaken in the Department of Animal Husbandry from November 26, 1946, to July 18, 1947.

PLAN OF THE STUDY

Three trials of 200 male ducklings each were made in this study. The birds in each trial were equally divided into two lots, each lot being housed separately. Lot II was provided with a 25-watt electric-light bulb which was used only during the feeding time at night, while lot I had no electric light. The ducklings were leg-banded and weighed to get their initial weights. Weighing was done every week thereafter till the end of the trial. The first trial was conducted for nine weeks, and the second and third trials, ten weeks each. The first trial was started on November 25, 1946; the second on February 12, 1947; and the third, on May 7, 1947.

Each lot was raised in separate pens, the floors of which were thickly littered with rice hulls. The ducklings had free access to a shady and grassy yard. The yard of each pen was divided into two smaller yards which were used alternately. Until the ducklings were about four weeks old, they were kept at night in low, rectangular wire boxes to keep away rats. The ducklings were not allowed to go out of the house until they were almost three weeks old. During this period, the door was opened in the morning to give the ducklings the benefit of the morning sunshine. When the ducklings were allowed to go out of the house, they were first provided with a small adjoining run. Later, they were allowed the use of the whole yard until the end of the experiment.

During the first few days, the feed consisted of a mixture of the prescribed ration mixed with boiled rice. The amount of boiled rice was gradually reduced until it was totally eliminated on the tenth feeding. The

[1]Experiment Station Contribution No. 1576. Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, 1948. Prepared in the Department of Animal Husbandry under the direction of Professor F. M. Fronda.

[2]FRONDA, F. M. 1929. Facts about the Philippine poultry industry. Poultry Item 31: 15, 32, 41, 64.

growing ration for ducklings recommended by Ancheta[3] was used in this study. It consisted of the following ingredients (all parts by weight):

Rice bran	56.25
Ground corn	18.75
Shrimp meal	25.00
Chopped green meal	*ad libitum*

The feed was given in the form of a sloppy mash in wooden troughs, 30 cm. by 100 cm. Lot I was fed four times a day—at 6:00 o'clock and at 10:00 o'clock in the morning, and at 2:00 and 6:00 o'clock in the afternoon. In addition to the usual daytime feeding, Lot II was given an extra feeding at 11:00 o'clock in the evening. The electric light was turned on only during the night feeding. The ducklings were given their feed in installments until they were satisfied. The extra feeding time normally lasted for about 15 minutes. Weekly feed consumptions of each lot were recorded at the end of every week. Clean drinking water was accessible to the birds at all times.

Records kept. The initial and weekly individual weights of the ducklings, the amount of feed consumed, the mortality, and the returns from the sale of green ducks were recorded.

RESULTS AND DISCUSSION

Rate of growth. Table 1 shows that there was not much difference in the initial weights of the ducklings in all the three trials. At the end of the second week, the weights had increased to almost three times the average initial weights in all the trials. At this age, Fronda and Cruz[4] observed that the male ducklings had almost doubled their weights. Among Muscovy ducks, Catalan[5] observed that the drakes doubled their initial weights at the end of the third week. Statistical analyses showed insignificant differences between the average weekly increase in weight of the ducklings fed normally and of those given an extra night feeding.

The average weight of the ducklings in lot I at the age of nine weeks in the first trial was 835.1∓22.76 grams; of those in lot II, 875.2∓20.39 grams. In the second trial, at the age of 10 weeks, it was 720.3∓21.40 grams in lot I, and 819.7∓22.31 grams in lot II. In the third trial, at the same age, the ducklings in lot I weighed 736.8∓22.11 grams and those in lot II, 836.7∓23.44 grams.

In the first trial, although the rate of gain of lot II was slightly higher than that of lot I, the difference was not significant. In the second and third trials, the rate of gain of lot II followed the general pattern of lot I, but from the eighth week, lot II had a faster rate of gain. In all the three trials, however, the differences in the rate of gain in weight were insignificant. The results of this experiment indicate that the increased weight of lot II was not big enough to warrant the practice of giving extra night feeding in the production of green ducks.

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[3]Ancheta, L. M. 1940. Observations on the influence of various methods of feeding ducklings. Philippine Agriculturist **29**: 262–271.

[4]Fronda, F. M. and G. B. Cruz. 1931. Preliminary studies on the possibilities of green duck production. Philippine Agriculturist **19**: 591–600.

[5]Catalan, L. V. Studies on the rate of growth of Muscovy ducks. (Thesis presented for graduation from the College of Agriculture, 1946. Unpublished).

On the whole, there was an appreciable amount of difference in the rate of growth of the ducklings in the different trials. This may be due to the differences in weather conditions at the time of the study. The ducklings in the first trial were raised from November 25, 1946, to January 27, 1947—a period when the weather seemed to be just ideal for their growth; the ducklings in the second trial were raised during the hot summer months; and those in the third trial, when it was partly rainy and partly hot.

Feed consumption and cost. The amount and cost of feed consumed in the three trials are shown in table 2. The feed consumption for nine weeks in the first trial was 254.0 kilograms in lot I and 315.6 kilograms in lot II. The actual feed consumption in ten weeks for the second and third trials averaged 300.3 kilograms for lot I and 372.3 kilograms for lot II. Fronda and Cruz reported that the actual feed consumption of the ducklings at ten weeks of age was 350.0 kilograms. The lower feed consumption of lot I in the present study may be accounted for by the fact that the birds were smaller than those used by Fronda and Cruz and that the percentage of mortality was greater.

At 32 centavos a kilogram, the current price of feed at the time of the experiment, the actual costs of feed consumed by the ducklings in nine weeks in the first trial were ₱81.28 for lot I and ₱100.49 for lot II. The actual cost of feed consumed in ten weeks for the second and third trials averaged ₱96.08 for lot I and ₱119.12 for lot II.

Due to the very high cost of feed, the cost of raising the ducks in the present study could not very well be compared with that reported by Fronda and Cruz. The amount of feed needed to produce a kilogram of green duck appears to be a better means of comparison. In this study, the ducks in lot I required an average of 4.63 kilograms of feed to produce a kilogram weight, whereas those in lot II required 4.96 kilograms. Fronda and Cruz reported that only 3.81 kilograms were needed to produce a kilogram weight for the same age. Lot II required more feed for every kilogram of weight than lot I because of the extra night feeding given to the former.

Mortality. The percentages of mortality in the different trials are shown in table 3. The most critical period in the life of the ducklings was the first few weeks after hatching. As the ducklings grew older, however, the percentage of mortality decreased. Deaths were due to chilling during sudden rains, and to rat depredation. Due to the nervous disposition of the ducklings, a slight disturbance would cause them to crowd in one corner of the pen or trample on one another, resulting in the death of the smaller ones. A few died from accidents in the management. The mortality in trial 1 was 22 per cent in lot I, and 21 per cent in lot II; in trial 2, 17 per cent in lot I, and 20 per cent in lot II; in trial 3, 27 per cent in lot I, and 20 per cent in lot II. The difference in mortality between lots I and II in all trials, however, was insignificant. On the average, lot I had a mortality of 22 per cent and lot II, 20.3 per cent. These results are much higher than the 10 per cent mortality reported by Fronda and Cruz.

Profit and loss. Table 4 shows the profit and loss statements. The ducklings in the first trial were sold at the age of nine weeks; those in the second and third trials, at ten weeks. At ₱1.50 a kilogram live weight, the ducklings in lot I in the first trial were valued at ₱97.71 and those in lot II, ₱103.71. When the total expenses, which included the cost of feed

consumed and the cost of the stock, were deducted from the total realized from the sale of the ducklings, there was a gross profit of ₱6.43 in lot I and a loss of ₱7.28 in lot II. In the second trial, both lots suffered losses, ₱19.20 in lot I and ₱34.58 in lot II. Likewise, in the third trial a loss of ₱22.60 was incurred in lot I, and a loss of ₱24.90 in lot II. These results are different from that obtained by Fronda and Cruz, who reported that a fair profit may be realized from the raising of green ducks. The difference in results may be attributed to the abnormally high costs of feed and stock when this experiment was conducted, and to the low selling price of the ducklings as compared with the expenses. Also, the average weight of the ducklings was very much lower than that reported by the aforesaid investigators. Another reason for the loss might have been the higher percentage of mortality in the present study.

In the study conducted by Fronda and Cruz, the feed was eight centavos a kilogram, and the green ducks were sold at 50 centavos a kilogram live weight. At this rate, the ratio between the cost of feed and the selling price of the meat was 1:6.25. In the present study, the ratio is only 1:4.69, based on 32 centavos a kilogram of feed and on ₱1.50 a kilogram weight of ducklings. If the ratio of 1:6.25 were followed, the ducklings should have been sold at ₱2.00 a kilogram in order to realize some profit.

SUMMARY

1. The most economical period of raising ducklings was observed to be when the ducklings were between the ages of one and seven weeks. After this period the increase in weight was no longer economical.

2. It needed 4.96 kilograms of feed to produce a kilogram weight when the ducklings were given extra night feeding and only 4.63 kilograms when no night feeding was given.

3. The average mortality was about the same in both lots, 22 per cent in lot I and 20.3 per cent in lot II.

4. The results seem to indicate that the slight increase in weight of the ducklings given an extra night feeding does not warrant the practice in the production of green ducks.

TABLE I

Average initial and final weights of the male ducklings in the three trials[a]

TRIAL NUMBER	LOT I			LOT II		
	Initial Weight	Final Weight	Average increase in weight	Initial Weight	Final Weight	Average increase in weight
	grams	*grams*	*grams*	*grams*	*grams*	*grams*
1	47.7∓0.42	835.1∓22.76	87.5	48.1∓0.51	875.2∓20.39	91.9
2	50.2∓0.43	720.3∓21.40	67.0	47.2∓0.69	819.7∓20.31	77.3
3	45.8∓0.47	736.8∓22.11	69.1	45.2∓0.46	836.7∓22.44	79.2

[a]The first trial was conducted for a period of nine weeks and the second and third trials, ten weeks each.

TABLE 2

Actual amounts and cost of feed consumed by the ducklings in the three trials[a]

TRIAL NUMBER	LOT I		LOT II	
	Feed consumed	Cost of feed consumed[b]	Feed consumed	Cost of feed consumed[b]
	kg.	*pesos*	*kg.*	*pesos*
1	254.0	81.28	315.6	100.99
2	309.0	98.88	384.2	122.94
3	291.5	93.28	360.3	115.30

[a]The first trial was conducted for a period of nine weeks and the second and third trials, ten weeks each.

[b]The cost of feed was 32 centavos a kilogram.

TABLE 3

Percentage of mortality of the ducklings in the three trials[a]

TRIAL NUMBER	MORTALITY	
	LOT I	LOT II
	per cent	*per cent*
1	22	21
2	17	20
3	27	20

[a]The first trial was conducted for a period of nine weeks and the second and third trials, ten weeks each.

TABLE 4

Financial statement

ITEMS	TRIAL 1[1]		TRIAL 2[2]		TRIAL 3[2]	
	Lot I	Lot II	Lot I	Lot II	Lot I	Lot II
	pesos	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*
Cost of 100 ducklings	10.00	10.00	10.00	10.00	10.00	10.00
Cost of feed consumed	81.28	100.99	98.88	122.94	93.28	115.30
Value of green ducks[3]	97.71	103.71	89.68	98.36	80.68	100.40
Gross profit	6.43	–7.28	–19.20	–34.58	–22.60	–24.90

[1]The ducklings were raised up to the age of nine weeks.

[2]The ducklings were raised up to the age of ten weeks.

[3]The green ducks were sold at ₱1.50 a kilogram live weight.

THE INFLUENCE UPON THE YIELD OF SWEET CORN OF THE NUMBER OF PLANTS IN A HILL[1]

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Of the Department of Agronomy

The experiment to determine the effects upon the yield of sweet corn of the number of plants in a hill was performed from October, 1942, to October, 1943, in the Department of Agronomy of the College of Agriculture at Los Baños, Laguna.

THE EXPERIMENT AND ITS RESULTS

The field of clay loam soil used for the wet- and the dry-season cultures was 5,000 square meters. The field was divided into 25 plots, each 20 meters long and 10 meters wide. The planting was randomized in the different plots to allow for analysis of variance. Each rate of seeding was replicated five times.

The land for the wet-season and the dry-season cultures was prepared in the same manner.

The seeds used were of Honey June corn shelled by hand from mass-selected ears from the Annual Farm Crops Division of the Department of Agronomy.

Seven to ten seeds were planted in a hill 80 cm. from each other in furrows one meter apart. Preliminary thinning was done two weeks after planting, when the seedlings were about 25 to 30 centimeters high. To allow for the damage that might result in cultivation before the final thinning, one plant more than the required rate of seeding was left in each hill. The final thinning was done when the plants were hilled up, leaving one, two, three, four, and five plants in a hill.

The dry-season culture was planted on December 15, 1942, hilled up with a native plow on February 1 and 2, 1943, and harvested on March 17, 1943, or about 91 days after planting. The wet-season culture was planted on May 10, 1943, hilled up on June 12 and 13, 1943, and harvested from July 26 to 27, 1943, or about 77 days after planting. Weeding was done by hand as often as necessary.

The corn stalks were cut close to the ground, the green ears picked from the plants, and the stalks from each hill weighed on a Fairbanks balance. The ears were classified as marketable or non-marketable, or nubbins, and weighed separately.

Owing probably to the difference in water content of the soil, more seeds germinated in the wet-season than in the dry-season culture.

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[1]Experiment Station Contribution No. 1577. Based on the thesis presented by the junior author for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, 1943. Prepared in the Department of Agronomy under the direction of the senior author.

The effects of the rate of seeding in the dry- and wet-season cultures were shown by rate of growth of plants, size of ears, size of stalks, and height of plants. Ears from the plots with fewer plants in a hill were larger than those with four or five plants.

There were no serious pests and diseases except the corn stem borer, *Pyrausta nubilalis* Hübner.

Table 1 shows that the variability in yield of marketable green ears was due to the treatment and placement of plots. However, the computed variance for treatment was comparatively higher than the blocks. This shows that a greater portion of the results was due to the treatment variance. It may be assumed therefore that in the wet-season culture, the production of marketable green ears varies correspondingly with the rate of seeding.

Table 1 also shows that three and four plants in a hill were significantly better than any of the other rates tried. The mean differences between the yields of three plants in a hill and those with two, five, or one plant were significant. However, the mean difference in yield between three and four plants in a hill was insignificant. These results conform with those of Juan[2] and Melegrito[3] who found that Pearl Pop corn and Lagkit corn did best when seeded at the rate of three and four plants to a hill. These results differ from that of Cabrillas[4] who noted that the Native Yellow Flint corn was best when planted at the rate of two and three plants to the hill.

The variation in yield of non-marketable ears in the wet-season culture was caused by the number of plants in a hill. The yield, however, was not affected significantly by the block as shown by the analysis of variance.

Furthermore, as the number of plants in a hill was increased, the production of non-marketable ears also increased. This may be due to the fact that the more plants there were in a hill, the weaker were the plants and the smaller were the ears produced. In fact, it was observed that about a week after the final thinning, the less plants there were in a hill, the more vigorous the plants grew, and vice versa. These results corroborate those of Ireland[5] who found that over-seeding caused the production of weaker plants with smaller and poorer ears. The seeding at the rate of five plants to a hill gave the highest yield of non-marketable ears.

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[2]Juan, Arsenio G. Effect upon the yield of Pearl Pop corn of varying the number of seeds to a hill. (Thesis presented for graduation with the degree of Bachelor of Science in Agriculture, 1939. Unpublished).

[3]Melegrito, Gregorio G. Effect upon the yield of Lagkit corn of varying the number of plants in a hill. (Thesis presented for graduation with the degree of Bachelor of Science in Agriculture, 1940. Unpublished).

[4]Cabrillas, Federico O. The effect upon the yield of Native Yellow Flint corn of varying the number of plants in a hill. (Thesis presented for graduation with the degree of Bachelor of Science in Agriculture, 1942. Unpublished).

[5]Ireland, H. A. 1910. Suggestions for growing corn in the Philippines. Philippine Agric. Rev. **3**: 450–459.

Table 2 shows that in the dry-season culture the variability in yield of marketable green ears was due to the treatment and block. However, the computed variance for treatment is higher than the block, showing that the treatment variance had a greater effect upon the yield.

Table 2 also shows that three and four plants in a hill were the best rates; the differences between their means and those of the other rates were significant.

The variability in yield of non-marketable ears was attributed to both the treatment and placement of plots, although the computed variance for treatment was higher than for the block. This shows that a greater portion of the effect was due to the treatment variance. It may be assumed therefore that in the dry-season culture, the production of non-marketable ears varies with the rate of seeding.

One, two, and three plants in a hill consistently produced significantly lower yield of non-marketable ears than the other rates. The yield of stover in the wet-season culture, as a whole, was affected by the number of plants in a hill as shown by the highly significant values of F for number of plants in a hill. The block did not affect significantly the yield of stover. Insignificant differences in the mean yields of stover between the last three rates of planting were obtained. However, significant differences in mean yields of stover were obtained between five plants in a hill and one and two plants in a hill, and between one and three plants in a hill.

The variability in yield of stover of the dry-season culture was affected both by the treatment and block as shown by the highly significant values of F. Five plants in a hill gave significantly a higher mean yield of stover than the other rates, although the mean differences between three and four, two and three, and one and two plants in a hill were all insignificant.

SUMMARY

1. In dry- and wet-season plantings of sweet corn, the highest yield of marketable green ears was obtained from the lots planted with three and four seeds in a hill.

2. The yield of non-marketable ears bore a direct relation to the number of plants in a hill; that is, the greater the number of plants in a hill, the higher the yield of non-marketable green ears.

3. A direct relation between the yield of stover and the rates of seeding was also obtained; the more seeds planted in a hill, the greater was the yield of stover.

TABLE 1

Yield in kilograms of marketable ears of Honey June corn to a plot of 200 square meters in the wet-season culture

PLANTS IN A HILL	BLOCK					PLANTS IN A HILL SUM	PLANTS IN A HILL MEAN[a]
	I	II	III	IV	V		
One.....	29.00	21.20	28.40	18.00	21.20	117.80	23.56
Two.....	35.00	31.60	37.00	16.60	40.20	160.40	32.08
Three....	43.60	36.00	41.00	36.80	41.00	198.40	39.68
Four.....	37.60	38.20	40.40	39.00	49.60	204.80	40.96
Five.....	20.40	34.20	32.00	23.20	37.80	147.60	29.52
Block sum...	165.60	161.20	178.80	133.60	189.80	829.00	—

[a]Least mean difference for plants in a hill is 6.566 kg.

Analysis of variance

SOURCES OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE VARIANCE	COMPUTED F-VALUE	TABULAR F-VALUE		REMARKS
					5%	1%	
Total.....	24	1841.36	—	—	—	—	—
Treatment.....	4	1049.63	262.4075	9.7384	3.01	4.77	H.S.
Block.....	4	360.60	90.1500	3.3456	3.01	4.77	S.
Error.....	16	431.13	26.9456	—	—	—	—

TABLE 2

Yield in kilograms of marketable ears of Honey June corn to a plot of 200 square meters in the dry-season culture

PLANTS IN A HILL	BLOCK					PLANTS IN A HILL SUM	PLANTS IN A HILL MEAN[a]
	I	II	III	IV	V		
One.....	6.20	11.00	7.80	3.60	7.60	36.20	7.24
Two.....	6.80	11.20	8.60	9.20	9.20	45.00	9.00
Three...	9.20	14.00	10.80	16.80	9.40	60.20	12.04
Four....	11.20	16.60	15.40	12.40	13.60	69.20	13.84
Five....	7.40	9.40	7.80	6.20	3.00	33.80	6.76
Block sum...	40.80	62.20	50.40	48.20	42.80	244.4	—

[a]Least mean difference for plants in a hill is 2.58 kg.

Analysis of variance

SOURCES OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE VARIANCE	COMPUTED F-VALUE	TABULAR F-VALUE		REMARKS
					5%	1%	
Total.....	24	312.820	—	—	—	—	—
Treatment.....	4	188.858	47.2145	11.1962	3.01	4.77	H.S.
Block.....	4	56.490	14.1225	3.3489	3.01	4.77	S.
Error.....	16	67.472	4.2170	—	—	—	—

WATER-TREATED COPRA MEAL AS A PROTEIN SUPPLEMENT IN A RATION FOR GROWING CHICKS[1]

Almario C. de los Santos

Copra meal is a cheap, easily available by-product in the Philippines. In spite of its fairly high protein content, it could not be used profitably in chick rations because of an unknown toxic substance or substances that it is suspected to contain. In a study on Los Baños Cantonese chicks, Fronda and Mallonga[2] found that a ration containing copra meal alone as protein supplement produced undersized weanlings. Eamilao[3] observed that the chicks fed rations containing 20 per cent or more of copra meal suffered a high mortality, and the weanlings produced were rather thin and very small for their age.

Raw soybean meal, which exhibits a similar toxic effect on chicks, was reported by Borchers *et al*[4] to be relieved of its toxicity if washed in 0.4 per cent NaCl solution. Borchers[5] suggested that water, dilute acid, or dilute salt extraction may draw out any possible harmful factor from seeds not improved by heating. Any simple and practicable device that will remove what is believed to be a growth inhibitor in copra meal will benefit the majority of local poultry raisers. Treating copra meal with water and then drying it are simple operations which can be performed easily by any poultryman. To determine the value of washed copra meal as a protein supplement in a ration for growing chicks, this study was performed in the Department of Animal Husbandry from July, 1948, to March, 1949.

MATERIALS AND METHODS

A total of 258 Los Baños Cantonese chicks artificially hatched from eggs laid by the College flock were used. Five trials, each consisting of a control lot and an experimental lot, were run. The chicks in each trial were equally divided between the lots and observed separately for 12 weeks.

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[1]Experiment Station Contribution No. 1578. Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, 1949. Prepared in the Department of Animal Husbandry under the direction of Professor F. M. Fronda.

[2]Fronda, F. M., and M. P. Mallonga. 1935. Protein supplements in poultry rations: V. Copra meal as a supplement in rations for growing chicks. Philippine Agriculturist **24**: 326–336.

[3]Eamilao, Dominador E. 1936. Protein supplements in poultry rations: IX. Studies to determine the best combination of copra meal and fish meal in rations for growing chicks. Philippine Agriculturist **26**: 688–696.

[4]Borchers, Raymond, *et al.* 1947. Trypsin inhibitor. V. Nutritive value of treated soybean oil meal and some characteristics of the trypsin inhibitor in soybeans. Nebraska Agric. Exper. Sta. Res. Bull. 152: 1–15.

[5]Communication dated February 10, 1948, received by Professor F. M. Fronda from Raymond Borchers of the Department of Agricultural Chemistry, University of Nebraska, Lincoln, Nebraska, U. S. A.

The rations used were composed of the following ingredients, all parts by weight:

FEEDS	LOT I	LOT II
Rice bran, fine	55	55
Ground corn	20	20
Fish meal	5	5
Copra meal (unwashed)	20	—
Copra meal, washed[6]	—	20

The rations were fed to the chicks in the form of dry mash made available to them at all hours during the day. All the chicks were given chopped green grass and sweet-potato leaves every day. The birds in all the lots were reared in identical brooding quarters and subjected to the same care and management until the age of 12 weeks.

The initial and biweekly weights of the birds, the weekly consumption of feed of each lot, and the percentage of mortality were recorded. The rate of feathering was observed.

DISCUSSION OF RESULTS

Rate of growth. The weights of the chicks at different ages are given in table 1. This table shows that there was no significant difference in the biweekly weights of the two lots throughout the experiment. On the twelfth week, the mean weight of the birds in lot I was 222.9∓13.05 grams and that of the birds in lot II, 231.2∓15.79 grams. On the basis of standard error of difference, no significant difference exists between the mean weights of the two lots. Similar results were observed in all of the trials made. The average weights of the weanlings in both lots were low. These figures, however, were higher than that reported by Eamilao (1936). These results showed that the feeding value of copra meal was not improved by washing it with water.

Feed consumption and feed cost. The total amounts of feed consumed by each chick in the whole brooding period were 2.91 kilograms for lot I and 2.77 kilograms for lot II, both being higher than the figure reported by Eamilao (1936). Both lots consumed unusually large amounts of feed to produce a kilogram gain (table 2). On the average, lot I required 14.80 kilograms and lot II, 13.54 kilograms of feed to produce a kilogram gain. A kilogram gain in lot I cost ₱3.43; in lot II, ₱3.29. Lot II was only 4.1 per cent more efficient than lot I.

Mortality. Table 2 also shows that the average percentages of mortality of both lots were high, 91.47 per cent in lot I and 88.37 per cent in lot II. Eamilao (1936), who used in one of his lots of chicks a ration similar to that fed to lot I in the present study, reported a mortality rate of only 46.5 per cent. The high mortality rates in the present study may be due to the prevalence of diseases which affected the birds. The feeds given them decreased their vitality. What is significant, however, is that no difference in mortality was noted between the two lots.

[6]Copra meal was soaked in water for 24 hours, and then dried with infra-red lamps after the steep water had been removed. Sunlight was not used because it may increase the vitamin D content of the washed copra meal.

Other observations. There was no appreciable difference in the rate of feathering among the chicks of both lots. All the birds exhibited retarded feather development. For this reason, they could not be definitely sexed at 12 weeks of age. The chicks in both lots looked sickly.

SUMMARY

1. No significant difference was observed in the mean weights of the 12-week-old chicks in both lots. The weanlings produced in both lots were very much undersized.

2. Both rations were apparently unpalatable to the chicks.

3. Both rations proved unprofitable in the production of weanlings. The ration supplemented with unwashed copra meal required 14.80 kilograms of feed to produce a kilogram gain; that supplemented with washed copra meal, 13.54 kilograms.

4. The mortality of the chicks in both lots was high, and there was no significant difference between the two.

5. The results obtained in this study seem to show that the feeding value of copra meal is not improved by washing it with water.

TABLE 1

Average biweekly weights of Los Baños Cantonese chicks

AGE	LOT I	LOT II
	grams	*grams*
1 day	26.5 ∓ 0.20	27.0 ∓ 0.24
2 weeks	38.3 ∓ 0.68	38.4 ∓ 0.61
4 weeks	56.8 ∓ 1.69	54.7 ∓ 1.37
6 weeks	79.9 ∓ 4.36	74.9 ∓ 3.07
8 weeks	102.5 ∓ 6.55	104.8 ∓ 6.43
10 weeks	151.4 ∓ 12.31	154.9 ∓ 9.82
12 weeks	222.9 ∓ 13.05	231.2 ∓ 15.79

TABLE 2

Amount and cost of feed required to produce a kilogram gain, and mortality of the chicks

ITEMS	LOT I	LOT II
Average weight of 100 day-old chicks, kilograms	2.65	2.70
Average weight of 100 weanlings at twelfth week, kilograms	22.29	23.12
Average gain in weight, kilograms	19.64	20.42
Total feed consumed by 100 chicks in twelve weeks, kilograms	290.7	276.5
Feed required to produce a kilogram gain, kilograms	14.80	13.54
Cost of feed to produce a kilogram gain, pesos	3.43	3.29
Mortality, per cent	91.47	88.37

THE BASE-EXCHANGE CAPACITY OF SOME UPLAND AND LOWLAND SOILS[1]

N. L. Galvez and Gabriel V. Aquino
Of the Department of Soils

Galvez (1936) in his study of plant food reserve in lowland and upland soils found that, although lowland soils were more intensively weathered than upland, both contained equal amounts of P_2O_5 and K_2O.

The base-exchange capacity of soils determines the rate at which fertilizer materials may be safely and economically applied. It not only preserves the essential cations in a form available to plants and yet not easily removable by water but also gears the various soil properties which influence plant growth and development.

Because of the various contributions of base exchange to soil fertility, a study of the base-exchange capacity of some upland and lowland soils was conducted in the Department of Soils from July, 1949, to October, 1950.

Lyon and Buckman (1949) cite Marshall who states that "next to photosynthesis, base exchange is the most important chemical reaction in the whole domain of agriculture." Although base exchange has been studied intensively elsewhere, work on this important chemical reaction in Philippine soils is yet very limited. Some data on base exchange of Philippine soils may be found in the works of King and Guanzon (1929), Aquino (1936), and Galvez (1939).

Truog and Chucks (1930) found that feldspar allowed to weather at pH 8.3 produced base-exchange materials and silica. They further reported that bentonite from volcanic dusts deposited in water having a pH of 8.4 easily decomposed into silica and base-exchange compounds.

Mitchell (1932) reported that soil organic base-exchange complexes may be destroyed by ignition at 350° to 400° C. without apparently affecting the exchangeable magnesium. He also found that a large portion of the exchange capacity of mineral soils is often due to the contents of organic matter, which differ greatly in their base-exchange capacities. The base exchange of organic matter is due to two fractions, the hemicellulose fraction and the lignin-humus; the latter is more important because it imparts a permanent base-exchange property to the soil.

McGeorge (1934) found that green manure residues, including plant roots, materially enhanced the exchange capacity of soils. He attributed this to the reaction of chemically equivalent amounts of cations of a salt solution and the absorbing fraction of the soil.

Frops and Fudge (1935) found a close relation between exchange capacity and the contents of soluble iron and aluminum oxide.

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[1]Experiment Station Contribution No. 1579; taken from the thesis presented by the junior author for graduation with the degree of Bachelor of Science in Agriculture, October, 1950. Prepared in the Department of Soils under the direction of the senior author.

In 1936, Millar, Smith and Brown observed that the composition of base-exchange compounds derived from organic matter differs according to the nature of the plant and bears no relation with the carbon content, acidhydrolyzable fractions, and alcohol-soluble materials of the plants. They also reported that as plant materials decomposed, they increased their exchange capacities many times more than they decreased their weight or lignin content.

Whitt and Baver (1937) showed that base exchange is related to the particle size of soil, that is, the capacity becomes lower as the particles grow bigger, and higher as surface area increased.

MATERIALS AND METHODS

Soil samples collected from adjoining unfertilized upland and lowland areas in different towns of Laguna were used in the present study.

San Pablo upland area is slightly rolling and discharges its surface runoff into the irrigation creek, which separates it from the lowland. The surface soil, which is about 25½ to 37½ cm. deep, is dark brown to almost black, and very friable. The area, although never fertilized, supports luxuriantly growing coconut trees. The soil, however, is kept in sod with grass locally known as "kulape" (*Paspalum conjugatum* Berg.). The subsoil is light brown.

The lowland area is level and planted to rice which, in spite of a sufficient supply of irrigation water, shows poor growth. The yield, which is about 30 cavans to a hectare in the wet season, varies with the planting season. All around are patches of stunted and chlorotic rice plants which are susceptible to lodging. The surface soil is light brown and is 7½ to 12½ cm. deep. It is hard when dry and very sticky when wet. The subsoil, which is brown to reddish, is sand and gravel.

Calauan upland is separated from the lowland by a creek used for irrigating the lowland fields. It is alternately planted to corn and rice. The soil is very friable and loose. The surface soil is brown to dark brown, and is 37½ to 50½ cm. deep. The average annual yield of corn is 15,000 ears to a hectare and that of rice, from 20 to 25 cavans. The surface soil and the subsoil do not differ much in color and texture.

The lowland area is level and planted to rice twice a year. The surface soil is black, and is 62½ to 75 cm. deep. Different materials actively undergoing decay, as indicated by the obnoxious odor, abound in the area. Irrigation water from a river is available the whole year round. In the dry season, the yield is 50 to 60 cavans of palay a hectare and in wet season, only 40 to 50 cavans.

Bay upland area is planted to coconut and some leguminous plants. The area, being level, has a very poor drainage. The soil is dark brown, sticky when wet, and hard when dry. Coffee is planted between the coconut trees. Since the owner could not give the average yield, no data was obtained.

The lowland area is generally level and is planted to rice twice a year; the annual yield is 65 to 75 cavans a hectare. The surface soil is dark brown

and very sticky, and is from 60 to 62 cm. deep. It contains an abundance of unidentified decaying materials. The subsoil is also dark brown and very sticky.

The College Experiment Station upland area is planted to coconut with leguminous crops between rows. These are mostly centrosema (*Centrosema plumieri* Benth.) and calopogonium (*Calopogonium mucunoides* Desv.). The place has a very good drainage. The surface soil, which is light brown, is about 12 to 36 cm. deep. The subsoil is stony and much lighter in color than the surface.

The lowland has a very poor drainage. It is light brown and very sticky. Rice, which is planted only during the rainy season because there is no irrigation water, shows poor growth. The surface soil is about 12 to 25 cm. deep. The subsoil is yellowish brown.

Calamba upland, being hilly, has an excessive drainage. The surface soil is loose and stony, light brown, and very friable. It is 36 to 40 cm. deep. Rice, as a major crop, yields 25 to 30 cavans a hectare each planting. Corn is planted as a secondary crop. The growth of these two crops in the different parts of the area is not uniform and is not so good as in other places.

The lowland, which is gently rolling, is planted to rice which shows very good growth. The surface soil is almost black with a reddish tinge, and is about 72 to 90 cm. deep. Irrigation water from a creek is available any time. Two plantings a year are done, with an average annual yield of 90 to 110 cavans.

Loss on ignition, water-holding capacity, and the mechanical analysis of the samples were carried out in accordance with the method described by Piper (1947); hygroscopicity, by the method of Wiessmann (1929); and pH values, by the potentiometric method with the use of Beckman glass electrode pH-meter. The amount of plant food held in reserve was determined by the method of the second commission of the International Society of Soil Science as modified by Blanck and Rieser (1928); that of the exchangeable bases replaced by normal neutral ammonium acetate, by the techniques of Merkle (1940).

RESULTS AND DISCUSSION

The loss on ignition varied with the soils. The lowest was that of the Calauan upland soils and the highest, that of Calamba lowland soils. This variation may be attributed to the system of soil management practiced in different localities. The loss on ignition of the upland soil ranged from 7.08 per cent (Calauan) to 9.77 per cent (Calamba), with a mean of 8.59 per cent; the lowland, from 8.21 per cent (San Pablo) to 11.88 per cent (Calamba), with a mean of 9.61 per cent. The two means, although with a fairly large difference, gave insignificant variation.

With regard to the water-holding capacity, the lowest value was given by Calauan upland and the highest, by Calamba lowland soils. The water-holding capacity of the upland varied from 49.88 per cent (Calauan) to 72.65 per cent (Calamba), with an average of 68.38 per cent. The lowland gave a range of 83.51 per cent (College Experiment Station) to 98.42

per cent (Calamba), with an average of 89.85 per cent. The two averages compared, a difference in favor of lowland soils was obtained. This may be attributed to the high organic-matter content of lowland soils.

Hygroscopicity varied in upland soils, ranging from 8.41 per cent (San Pablo) to 31.43 per cent (Calauan), giving an average of 15.40 per cent; in lowland, from 11.99 per cent (Calauan) to 17.11 per cent (Bay), with a mean of 14.67 per cent. These means are statistically similar.

The pH value did not vary appreciably in the different samples. The pH value of upland soils ranged from 6.10 (College Experiment Station) to 7.05 per cent (Calauan), with a mean of 6.64 per cent; that of lowland, from 6.28 per cent (College Experiment Station) to 7.32 per cent (Calauan), with a mean of 6.65 per cent. These variations are insignificant. The pH values of all the samples were within the reaction tolerance of the soil flora.

Although the amount of clay and silt in both upland and lowland soils varied appreciably with the samples, the mean values of clay and silt in upland soils showed no real deviations from those in the lowland.

Table 2 shows that the amount of silica soluble in 10 per cent HCl varied in upland soils from 1.80 per cent (Bay) to as high as 4.81 per cent (San Pablo), with a mean of 2.69 per cent; that in the lowland, from 2.23 per cent (Bay) to 2.72 per cent (Calauan), with an average of 2.39 per cent. The two means show no appreciable difference.

The sesquioxides in upland samples ranged from 12.23 per cent (Bay) to 13.38 per cent (San Pablo), with a mean of 12.73 per cent; those of lowland, from 12.15 per cent (San Pablo) to 13.07 per cent (Calamba), with means of 12.73 per cent and 12.61 per cent, respectively. Apparently, they did not deviate from each other. The amount of Al_2O_3, Fe_2O_3, and P_2O_5 showed similar trend of results.

The calcium content of upland soils ranged from 0.87 per cent (Calamba) to 1.00 per cent (San Pablo), with a mean of 0.94 per cent; that of lowland, from 0.83 per cent (College Experiment Station) to 0.96 per cent (San Pablo and Calauan), with a mean of 0.92 per cent. These means have no significant difference. According to Bieler, as cited by Galvez (1936), soils containing 0.50 to 1.00 per cent lime were not deficient in it. The lime contents of the ten different soil samples used in this study were within the given range.

The magnesium content of upland soils varied from 0.46 per cent (College Experiment Station) to 0.59 per cent (Calamba), with a mean of 0.53 per cent; that of lowland, from 0.49 per cent (San Pablo) to 0.55 per cent (Calamba), with means of 0.53 per cent and 0.52 per cent, respectively. The difference between the two means is insignificant.

The potash content of upland soils ranged from 1.44 per cent (College Experiment Station) to 1.63 per cent (Calamba), with a mean of 1.55 per cent; that of lowland soils, from 1.08 per cent (Calauan) to 1.62 per cent (San Pablo), with a mean of 1.46 per cent. When compared, the two means were found to be identical. Weibul, as cited by Galvez (1936), found that light soils containing 0.15 per cent K_2O may not respond to the application of potassic fertilizers. All the samples used in the present study exceeded this percentage of K_2O.

The sodium content of upland soils ranged from 0.69 per cent (Bay) to 0.80 per cent (Calamba), with a mean of 0.72 per cent. The lowland gave a range from 0.65 per cent (San Pablo) to 0.80 per cent (College Experiment Station), with a mean of 0.73 per cent which was very close to that of the upland.

It is apparent in table 3 that the base-exchange capacity of upland and lowland soils, like the other soil variates, varied with the samples. In upland soils, the range was from 8.58 (Calauan) to 9.80 (Bay) and in lowland, from 9.72 (Calamba) to 11.90 (San Pablo), giving means of 9.26 and 10.83 milligram equivalents per 100 grams soil, respectively. The significant difference in favor of lowland soils may be attributed to their high organic matter content. Galvez (1936) found that lowland soils contained 3.56 per cent organic matter whereas the upland, only 3.02 per cent.

The amount of exchangeable calcium (table 3) in the ten soils studied varied with the soils. In upland soils, the amount ranged from 3.13 (Bay) to 4.14 (Calauan) and in the lowland, 3.16 (Calamba) to 4.29 (Bay), giving means of 3.53 and 3.66 milligram equivalents per 100 grams of soil, respectively.

The exchangeable magnesium, although much less in amount, behaved in the same manner as that of calcium in that different soils contained different amounts. The mean of upland soils did not vary appreciably from that of the lowland.

The amount of exchangeable potassium, like the amounts of the two bivalent exchangeable bases, varied with the samples. The upland soils showed a range from 0.99 (Calamba) to 1.46 (Bay) and the lowland, from 0.88 (Calamba) to 1.60 (San Pablo), with means of 1.21 and 1.23 milligram equivalents per 100 grams of soil, respectively. Statistically, these two means are identical.

Unlike the three essential exchangeable bases, the amount of sodium in both upland and lowland soils not only exceeded the other three cations but also exhibited wider ranges. In upland soils, it varied from 1.12 (Calauan) to 3.86 (Bay); in the lowland, from 3.56 (Bay) to 4.90 (San Pablo), giving means of 2.87 and 4.21 milligram equivalents per 100 grams of soil, respectively. These two means compared, lowland soils proved to exceed upland soils. As sodium ion has the ability not only to defloculate fine soil particles but also to induce compact condition of soil particles with the tendency to become impervious, the relatively high value of exchangeable sodium may account for the slow percolation rate of soil solution in lowland soil profile.

Further study of the figures in table 3 showed that of the three most important exchangeable bases in soils, calcium had the highest amount, magnesium, second; and potassium, the least. These findings were in accord with those of Galvez (1939).

It is obvious in table 4 that the base-exchange capacity of upland soils was independent not only of its content of Fe_2O_3, Al_2O_3, SiO_2, sesquioxides and silt clay, but also of pH value. Further assessment of the data in this table showed that while the base-exchange capacity of lowland soils decreased as its Al_2O_3, sesquioxides, and silt + clay content increased, it was not affected by its content of Fe_2O_3 and SiO_2 and by its pH value.

SUMMARY

1. Although the pH values, the percentages of silt, clay, and loss on ignition of lowland and upland soils were similar, the water-holding capacity of the former was higher than that of the latter.

2. The amount of the chief soil constituents, namely, SiO_2, Al_2O_3, CaO, MgO, K_2O, and Na_2O, dissolved by 10 per cent HCl, was identical for both soils.

3. Lowland soils showed higher base-exchange capacity than the upland.

4. Although the amount of exchangeable calcium, magnesium, and potassium in lowland soils was the same as that in upland, the amount of sodium was higher in the former than in the latter.

5. The base-exchange capacity of both lowland and upland soils showed no correlation with their pH values and Fe_2O_3 and SiO_2 content.

LITERATURE CITED

Aquino, D. I. 1936. A study of the base exchange properties of certain Philippine soils. Philippine Agriculturist **25**: 128–144.

Blanck, E., and A. Rieser. 1928. Bieträge zur Methodik der Bodenauszüge nach der Salzsäure-Methode. Jour. f. Landwirtschaft **76**: 25–31.

Frops, G. S., and J. F. Fudge. 1935. Decomposition of the base exchange compounds of soils by acids and its relation to the quantity of alumina and silica dissolved. Jour. Amer. Soc. Agron. **27**: 446–456.

Galvez, N. L. 1936. Plant-food reserve in lowland and upland soils. Philippine Agriculturist **25**: 221–232.

Galvez, N. L. 1939. A study of the base forming elements in soils. Philippine Agriculturist **28**: 143–151.

King, R. H., and G. Guanzon. 1929. Base exchange of some Philippine soils. Sugar News **10**: 893–931.

Lyon, T. L., and H. O. Buckman, 1939. The nature and properties of soils. 4th. ed. xi + 499 p. New York: The Macmillan Company.

McGeorge, W. T. 1934. Organic base exchange compounds in soils. Jour. Amer. Soc. Agron. **26**: 575–579.

Merkle, F. G. 1940. Soil testing, operation, interpretation, and application. Penn. State Coll. Agric. Exper. Sta. Bull. 398: 1–34 *Fig. 1–6*.

Millar, H. C., F. B. Smith, and P. E. Brown. 1936. The base exchange compounds of decomposing organic matter. Jour. Amer. Soc. Agron. **28**: 753–766.

Mitchell, John. 1932. The origin, nature, and importance of soil organic constituents having base exchange properties. Jour. Amer. Soc. Agron. **24**: 256–275.

Truog, E., and J. A. Chucka. 1930. The origin, nature, and isolation of the inorganic base exchange compounds of soils. Jour. Amer. Soc. Agron. **22**: 553–557.

Whitt, D. M., and L. D. Baver. 1937. Particle size in relation to base exchange and hydration properties of Putnam clay. Jour. Amer. Soc. Agron. **26**: 575–579.

Wiessmann, H. 1926. Agrikulturchemisches Praktikum Quantitative Analyse. ix + 329 p. Berlin: Verlagsbuchhandlung Paul Parey.

TABLE 1A

Physical properties of upland and lowland soils

PHYSICAL PROPERTIES	SAN PABLO		CALAUAN		BAY		COLLEGE EXPER. STA.		CALAMBA		MEAN		COMPUTED "T"	REMARKS
	Sandy clay loam	Sandy clay loam	Sandy clay loam	Clay	Clay loam	Sandy clay	Clay loam	Clay	Clay	Clay				
	Upland	Lowland	Upland	Lowland	Upland	Lowland	Upland	Lowland	Upland	Lowland	Upland	Lowland		
Loss on ignition (per cent)	8.81	8.21	7.08	9.35	8.29	9.41	8.98	9.18	9.77	11.88	8.59	9.61	1.353	Insignificant
Water-holding capacity (per cent)	66.68	87.20	49.88	88.60	72.30	91.53	70.37	83.51	72.65	98.42	66.38	89.85	4.753	Significant
Hygroscopicity (per cent)	8.41	16.20	31.43	11.99	12.65	17.11	12.52	13.30	12.01	14.76	15.40	14.67	0.174	Insignificant
pH value	6.70	6.68	7.05	7.32	7.01	6.46	6.10	6.28	6.28	6.56	6.64	6.66	0.025	Insignificant

Tabular "t" at
5% level = 2.306

TABLE 1B

Mechanical analyses of upland and lowland soils

TEXTURE	SAN PABLO		CALAUAN		BAY		COLLEGE EXPER. STA.		CALAMBA		MEAN		COMPUTED "T"	REMARKS
	Sandy clay loam	Sandy clay loam	Sandy Clay loam	Clay	Clay loam	Sandy clay	Clay loam	Clay	Clay	Clay				
	Upland	Lowland	Upland	Lowland	Upland	Lowland	Upland	Lowland	Upland	Lowland	Upland	Lowland		
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*		
Clay	24.80	28.97	25.67	33.47	28.34	39.50	30.60	35.86	37.72	41.74	29.43	35.91	2.009	Insignificant
Silt	23.60	14.49	19.27	20.47	24.58	6.03	31.04	29.12	27.36	28.48	25.17	19.72	1.140	Insignificant
Sum	48.40	43.46	44.94	53.94	52.92	45.53	61.64	64.98	65.08	70.22	54.60	55.63	—	—
Sand	51.60	56.54	55.06	46.06	47.08	54.47	38.36	35.02	34.92	29.78	45.40	44.37	0.158	Insignificant

Tabular "t" at 5% = 2.306

TABLE 2

Analyses of the 10% HCl extract of upland and lowland soils

PLANT FOOD HELD IN RESERVE	SAN PABLO		CALAUAN		BAY		COLLEGE EXPER. STA.		CALAMBA		MEAN		COMPUTED "t"	REMARKS
	Sandy clay loam	Sandy clay loam	Sandy clay loam	Clay	Clay loam	Sandy clay	Clay loam	Clay	Clay	Clay				
	Upland	Lowland	Upland	lowland	Upland	Lowland	Upland	Lowland	Upland	Lowland	Upland	Lowland		
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*		
SiO_2	4.81	2.32	2.48	2.72	1.80	2.23	1.91	2.28	2.46	2.40	2.69	2.39	0.542	Insignificant
Sesquioxides	13.38	12.15	12.76	12.39	12.23	12.59	13.02	12.85	12.27	13.07	12.73	12.61	0.437	Insignificant
Al_2O_3	9.86	8.95	9.70	9.23	8.97	9.30	9.52	9.76	8.92	9.63	9.39	9.37	0.083	Insignificant
Fe_2O_3	3.42	3.11	2.94	3.09	3.18	3.20	3.37	2.98	3.28	3.35	3.24	3.15	0.857	Insignificant
P_2O_5	0.10	0.09	0.12	0.07	0.08	0.09	0.13	0.11	0.07	0.09	0.10	0.09	0.769	Insignificant
CaO	1.00	0.96	0.94	0.96	0.89	0.92	0.98	0.83	0.87	0.93	0.94	0.92	0.571	Insignificant
MgO	0.52	0.49	0.56	0.50	0.51	0.53	0.46	0.52	0.59	0.55	0.53	0.52	0.400	Insignificant
K_2O	1.60	1.62	1.57	1.08	1.53	1.48	1.44	1.56	1.63	1.55	1.55	1.46	0.874	Insignificant
Na_2O	0.72	0.65	0.70	0.68	0.69	0.75	0.71	0.80	0.80	0.76	0.72	0.73	0.294	Insignificant

Tabular "t" at
5% level = 2.306

TABLE 3

Exchangeable bases of upland and lowland soils in milligram equivalents per 100 grams

EXCHANGEABLE BASES	SAN PABLO		CALAUAN		BAY		COLLEGE EXPER. STA.		CALAMBA		MEAN		COMPUTED "t"	REMARKS
	Sandy clay loam	Sandy clay loam	Sandy clay loam	Clay	Clay loam	Sandy clay	Clay loam	Clay	Clay	Clay				
	Upland	Lowland	Upland	Lowland	Upland	Lowland	Upland	Lowland	Upland	Lowland	Upland	Lowland		
	m.e.	*m.e.*	*m.e.*	*m.e.*	*m.e.*	*m.e.*	*m.e.*	*m.e.*	*m.e.*	*m.e.*	*m.e.*	*m.e.*		
Ca	3.67	3.45	4.14	4.14	3.13	4.29	3.19	3.25	3.50	3.16	3.53	3.66	0.439	Insignificant
Mg	1.91	1.95	2.18	2.03	1.35	1.79	1.38	1.38	1.44	1.48	1.65	1.73	0.381	Insignificant
K	1.38	1.60	1.14	0.87	1.46	1.56	1.08	1.22	0.99	0.88	1.21	1.23	0.110	Insignificant
Na	2.46	4.90	1.12	4.23	3.86	3.56	3.13	4.14	3.79	4.20	2.87	4.21	2.441	Significant
Total	9.42	11.90	8.58	11.27	9.80	11.20	8.78	9.99	9.72	9.72	9.26	10.83	2.99	Significant

Tabular "t" at 5% level = 2.306

TABLE 4

Correlation of base-exchange capacity with related soil variates

BASE-EXCHANGE CAPACITY AND RELATED SOIL VARIATES	COMPUTED "R"		REMARKS	
	Upland	Lowland	Upland	Lowland
Base-exchange capacity and Fe_2O_3.....	+0.069	—0.058	Ins.	Ins.
Base-exchange capacity and Al_2O_3.....	—0.152	—0.960	Ins.	Sig.
Base-exchange capacity and SiO_2.....	—0.034	+0.128	Ins.	Ins.
Base-exchange capacity and silt + clay...	+0.783	—0.952	Ins.	Sig.
Base-exchange capacity and pH.....	—0.009	+0.452	Ins.	Ins.
Base-exchange capacity and sesquioxides..	—0.097	—0.974	Ins.	Sig.

Ins.—Insignificant correlation

Sig.—Significant correlation

Tabular "r" at 5% level = 0.878

COLLEGE AND ALUMNI NOTES

Mr. C. R. Eskildsen, agricultural adviser, ECA, Manila, visited the College on January 20, 1951, in connection with the rehabilitation of its experiment station. He was accompanied by Dr. Amando M. Dalisay, '37, executive secretary of the PCUSA, and Atty. Cornelio V. Crucillo, '25, of the National Economic Council.

Dr. Herbert E. Gregory, director emeritus of the Bishop Museum in Honolulu, former Silliman professor of geology at Yale University, chairman of the board of regents of the University of Hawaii, and one of the organizers of the Pacific Science Congress, visited the campus on January 29, 1951. He was accompanied by Dean Patrocinio Valenzuela of the College of Pharmacy, U.P. Doctor Gregory spoke at a special convocation.

Dr. and Mrs. Gregory, in a letter, thanked Dean and Mrs. Uichanco and the College constituency for making their visit a very pleasant one and stated, "The gathering of your students was a real pleasure to us; we enjoyed your trees and your flowers, your experiment station, your hills, and all we learned of your work."

Dr. Robert R. Williams, one of the world's foremost authorities on dietary diseases, was the guest of honor at the sixteenth initiation exercises of the Society for the Advancement of Research, which was held last February 2, 1951, at the Chemistry Lecture Hall. He was introduced by Secretary Juan Salcedo, Jr., of the Department of Health. The initiates present were: (to associate membership) Pablo Alfonso, Jr., Fabiana E. Alviar, Thomas G. Flores, José S. Gutierrez, Jorge P. Juliano, Domingo M. Lantican, and Leonardo A. Paulino; (to active membership) Dr. Isabelo Concepcion, Dr. Juan Salcedo, Jr., Dr. Faustino T. Orillo, and Dr. José R. Velasco.

Professor Calixto Mabesa, president of the society, read a paper on the progress of wood technology in the Philippines. Dr. V. C. Calma, vice-president, gave the introductory remarks. Dr. Getulio B. Viado is the secretary and Dr. Silverio M. Cendaña, the treasurer of the society.

Dr. Deogracias Villadolid, '19, director of fisheries, represented the Philippines at the meeting of the Indo-Pacific Fisheries Council at Madras, South India, from February 1 to 16, 1951. Dr. Villadolid was elected chairman of the Council.

Dr. F. O. Santos, head of the Department of Agricultural Chemistry, read a paper entitled "Some suggestions on diet for U.P. students in Diliman," at a meeting of the U.P. Council Committee on Students' Living Conditions on February 20, 1951.

Dr. Harold Jefferson Coolidge, executive secretary of the Pacific Science Board of the National Research Council of the United States, was the guest speaker at a special convocation on February 21, 1951. He was accompanied by Doctors Patrocinio Valenzuela and Alfredo C. Santos, of the U.P. College of Pharmacy.

The 198th scientific meeting of the Los Baños Biological Club was held on Friday afternoon, January 26, 1951, at the Agricultural Chemistry Lecture Hall. Mr. José S. Gutierrez, of the Department of Agricultural Chemistry, read a paper on the continuous extraction of coconut oil with the use of ethyl alcohol. In the 199th scientific meeting of the Club on February 23, 1951, Professor Alejandro B. Catambay, head of the Department of Agricultural Engineering, read a paper on the mechanization of rice production.

Reynaldo G. Marquez, a sophomore, was awarded a UNESCO scholarship which entitles him to a four-year study of agriculture at the University of Sydney, Australia. He left for Australia on February 27, 1951.

In the College, Marquez was a U.P. representative to the Student Council, president of the Sophomore Class, editor-in-chief of the *Aggie Green and Gold*, and a College and Madrigal scholar.

Lt. Col. Osmundo Mondoñedo, '34, assistant chief of air staff of the Philippine Air Force, was awarded the U.S. Legion of Merit during the formal presentation ceremony held at Nichols Air Base, in recognition of exceptionally meritorious conduct in the performance of his duty when he served as Philippine assistant military attaché for air to United States.

Major Jacinto B. Leoncio, '30, is commander of a combat battalion of the Philippine Army at the First Area Command.

Mr. Arcadio G. Matela, '29, was recently appointed president of the newly created Central Luzon Agricultural College by President Quirino. He holds a Master's degree in agricultural education and was acting superintendent of the CLAS before his appointment to the new position.

Prof. José Q. Dacanay, '15, accompanied his students in agricultural economics at Far Eastern University when they visited the College on March 4, 1951. With them were students under Dr. Eustaquio Aquino. Mr. Nathaniel B. Tablante, '46, of the Department of Agricultural Economics of the College, gave the visitors a lecture on farm management.

Mr. Eligio J. Tavanlar, '25, is at present head of the engineering department of the National University.

Dr. José M. Capinpin, '20, associate professor of agricultural botany, was appointed personal representative of President Dodds of Princeton University at the inauguration of the University of the East and induction into office of its first president on January 28, 1951.

The following alumni spoke at the recent symposium on lime and fertilizers, held under the auspices of the Soil Science Society of the Philippines at the Soil Conservation Building in Manila: Dr. Manuel L. Roxas, '11, Mr. Jesus P. Mamisao, '30, and Mr. Ricardo T. Marfori, '30. Mr. Dominador Z. Rosell, '28, is president of the society.

Dr. E. B. Copeland acknowledged receipt of a copy of *Philippine Agriculture:* I. *Field Crops*, about which he wrote as follows: "It is a magnificent job, a worthy demonstration of the work of the College."

A party composed of Mr. John V. Hepler, Mr. Francisco Galang, '14, and Mr. Rufino Isidro, '20, visited the College recently. They discussed with the College authorities problems of extension work.

Dr. Gonzalo Merino, '14, was recently appointed Director of the Bureau of Plant Industry. At the time of his appointment, he was chief of the Division of Pest and Disease Control of the bureau.

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